TUBERCULOUS EMPYEMA

in

ARTIFICIAL PNEUMOTHORAX

Thesis presented for the Degree

of

M. D.

by

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INTRODUCTION

This thesis consists of a study of 78 patients in whom eighty one empyemata occurred during treatment by artificial pneumothorax. Investigation covers etiology and treatment of these eighty one empyemata and survival of the seventy eight patients.

The objects of this study were :-

1. To ascertain the principal factors responsible for the occurrence of empyema in these patients.
2. To ascertain survival following different types of treatment.
3. To evaluate treatment.
4. To consider how empyema could have been avoided in the treatment of these cases.

MATERIAL

Eighty-one empyemata occurred in seventy-eight patients, made up as follows :-

1. Fifty cases (61.7%) occurred in patients with unilateral pneumothoraces.
2. Twenty-five cases (30.9%) occurred as unilateral

empyemata in bilateral pneumothoraces.

3. Six cases (7.4%) occurred in three patients with bilateral pneumothoraces.

The eighty-one empyemata considered in this thesis comprised 83.5% of the total number of ninety-seven empyemata which occurred in 1,448 consecutive pneumothraces induced in the Cheshire Joint Sanatorium, Market Drayton, Salop, during a period of eight years from 1st July, 1937 to 30th June, 1945.

Only cases in which tubercle bacilli had been demonstrated were included in the investigation, hence the rejection of sixteen of the total number of ninety-seven cases.

Thirty-five (43.2%) of the eighty-one empyemata investigated became secondarily infected with pyogenic organisms. These cases are referred to in the text as mixed Group B empyemata. The remaining forty-six cases (56.8%) of the total number of eighty-one are termed "pure" Group A empyemata.

This series of artificial pneumothoraces is a selected one in so far as

1. The period 1937 to 1945 was chosen for study deliberately, to ascertain the incidence of empyema during that time. The reasons were, firstly, that it was considered in the light of subsequent experience

that a large number of "bad" pneumothoraces were induced in the Sanatorium during those years. By the term "bad" is meant that while risks have occasionally to be taken in the choice of patients to be treated by pneumothorax, too many patients known now to be unsuitable for that type of treatment were in fact treated by artificial pneumothorax during the period under review. On the other hand, it must be remembered that many patients included in this series who were known at the time to be bad risks for pneumothorax treatment were destined to die more or less quickly unless some attempt were made to arrest their disease.

2. All the pneumothoraces were induced in one Institution by the same team of physicians. Almost all the adhesion sections by closed pneumolysis were performed by one member of the team. He had extensive experience of the treatment of pulmonary tuberculosis and in particular of the operation of internal closed pneumolysis.

Follow-up of the patients under review was considered until 31st December 1949. Thus the longest possible period of survival was 11½ years and the shortest 3½ years.

Certain disadvantages arise in a relatively

long period follow-up when considering a disease with a high mortality rate such as tuberculous empyema.

The first disadvantage is the need for greater dependence on records, and in particular on their accuracy. More recent cases offer the possibility and opportunity, as was provided in some included in this review, of personal examination of the patient, with comparison of original and most recent skiagrams.

The second disadvantage of a long period follow-up is that it tends to increase the number of cases coming into the category "lost sight of": in the 78 patients under review, six (7.7%) were lost sight of. Two of these six patients were known to be alive at the end of 1948 and were in fact "lost sight of" for only one year. The records of the other four patients had been lost or destroyed.

The third disadvantage applies to all follow-up procedures in a study of treatment of tuberculosis patients. Factors such as the tendency of the disease to self-healing, the individual resistance and temperament of patients, the influence of home, social and working environment and occupation must; in a long term follow-up, have a bearing on the survival of patients, and the longer the follow-up the greater the effect of these

outside influences is likely to be. Such imponderables make it almost impossible to set up valid standards for treatment in so protean a disease as pulmonary tuberculosis. On the other hand, too short a period of follow-up fails to cover the whole disease process and tends to put treatment in a perspective too false to permit of any valid conclusions being drawn therefrom. Similarly, the chronicity of pulmonary tuberculosis raises the question of the minimum period of time for which observation is necessary to reach reasonable and sound conclusions.

Finally, it will be appreciated that a series of only 78 cases is too small for elaborate statistical evaluation. Such statistics as are included in this Thesis are, therefore, very simple.

This Thesis is divided into four parts, as follows:-

Part 1 deals with the definition of Tuberculous Empyema as understood in this review and with the incidence age and sex distribution in the 78 patients being studied.

Part 2 is devoted to Etiology.

Part 3 deals with Treatment and Results.

Part 4 is devoted to Discussion and Conclusions.

PART 1

DEFINITION

The definition of empyema in artificial pneumothorax applied in this series is similar to that used by Dickey(1943), that the exudate should be turbid or purulent and that the tubercle bacillus have been demonstrated in the aspirated fluid , either on direct smear examination , or on culture or by animal inoculation.

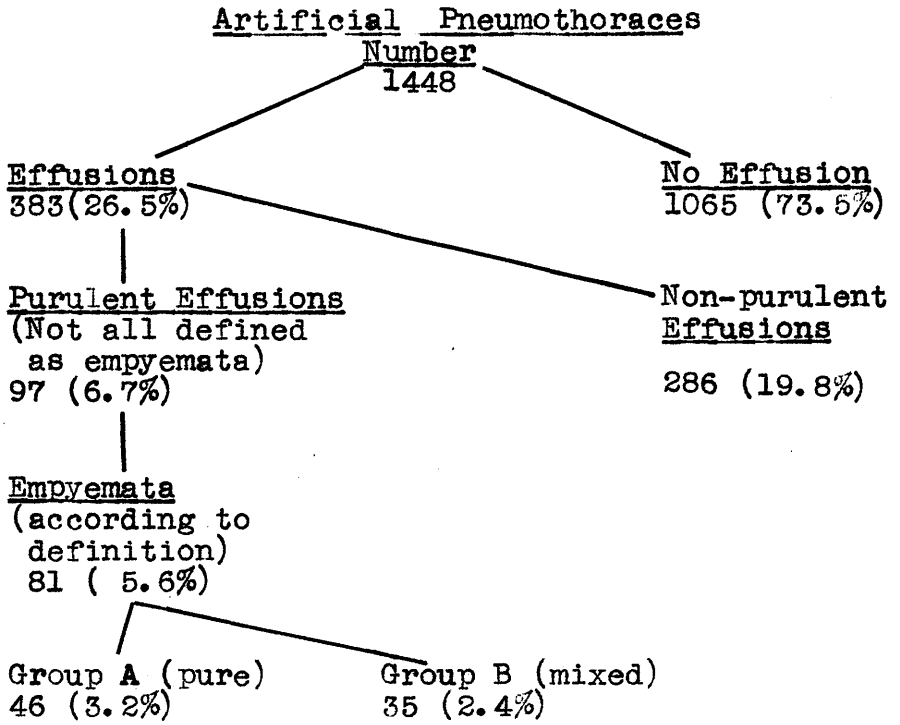
INCIDENCE

The incidence of empyema in artificial pneumothorax varies according to the definition used. In this series there were altogether ninety- seven empyemata in a total of fourteen hundred and forty eight consecutive pneumothoraces. Applying the definition quoted above , sixteen cases (16.5%) were discarded because tubercle bacilli were never at any time demonstrated in the exudate.

The incidence of empyema in this series of pneumothoraces is, therefore, as shown in Table I, page 7.

TABLE I

Incidence of Empyema in 1448 Consecutive Pneumothoraces



Effusion into pneumothorax in the above Table refers only to exudates which progressed at least to the level of the 5th costal cartilage or higher when viewed on the fluoroscopic screen or on skiagram.

Puddles of fluid over the diaphragm or in the costo-phrenic angle are not held to be effusions as understood in this series. The vast majority of these small effusions are temporary and evanescent and occur in all pneumothoraces at one time or another.

All effusions occurred while patients were in the Sanatorium, but four of the 81 empyemata

occurred in patients after discharge from the Sanatorium following satisfactory, or apparently satisfactory, treatment of the effusion.

SEX AND AGE INCIDENCE

78 Patients

The sex incidence was as shown in Tables 2 and 3. The age incidence was as shown in Tables 4 to 7.

TABLE 2

Sex and Age Incidence

78 Patients

Sex incidence was:-	Males	42	53.7%
	Females	36	46.3%
	Total	78	100.0%

	Males	%	Females	%	Total	%
Unilateral pneumothorax and empyema	31	39.6	19	24.4	50	64.0
Bilateral pneumothoraces and unilateral empyema	9	11.5	16	20.6	25	32.1
Bilateral pneumothoraces and bilateral empyema	2	2.6	1	1.3	3	3.9
Total	42	53.7	36	46.3	78	100.0

Group A and Group B Cases

Thirty-four of the 78 patients (43.6%) had their empyemata secondarily infected. One patient with bilateral empyema had both sides pyogenically infected. Thus thirty-five of the 81 empyemata fall into Group B, equivalent to 43.2% of the total number of empyemata. Forty -four(56.4%) of the 78 patients and forty six(56.8%) of the 81 empyemata fall into Group A- pure tuberculous empyema. The sex incidence in Group B cases is shown in Table 3.

TABLE 3

Sex Incidence - Group B - 34 Patients.

	Males		Females			
	No.	%	No.	%	Total	%
Unilateral empyema in unilateral pneumothorax	14	41.2	8	23.5	22	64.7
Bilateral pneumothorax unilateral empyema	3	8.8	6	17.7	9	26.5
Bilateral pneumothorax and bilateral empyema	2	5.9	1	2.9	3	8.8
Total -----	19	55.9	15	44.1	34	100.0

In Group B,one of the bilateral empyema cases,

a man had both empyemata secondarily infected. Thus 20 (57.1%) of the total of 35 secondarily infected pneumothoraces occurred in men, and 15 (42.9%) in women.

Age distribution is shown in Table 4 below.

TABLE 4

Age Distribution - 78 Patients

Age distribution on admission was as follows:-

Age Group	Males	Females	Total	Per cent
15-19	5	5	10	12.8
20-24	13	13	26	33.3
25-29	6	8	14	17.9
30-34	9	7	16	20.5
34-39	5	2	7	9.0
40-44	1	1	2	2.6
45-49	2	0	2	2.6
50-54	1	0	1	1.3
Over 54	0	0	0	
Total	42	36	78	100.0

TABLE 5

Combined Age & Sex Distribution

78 Patients.

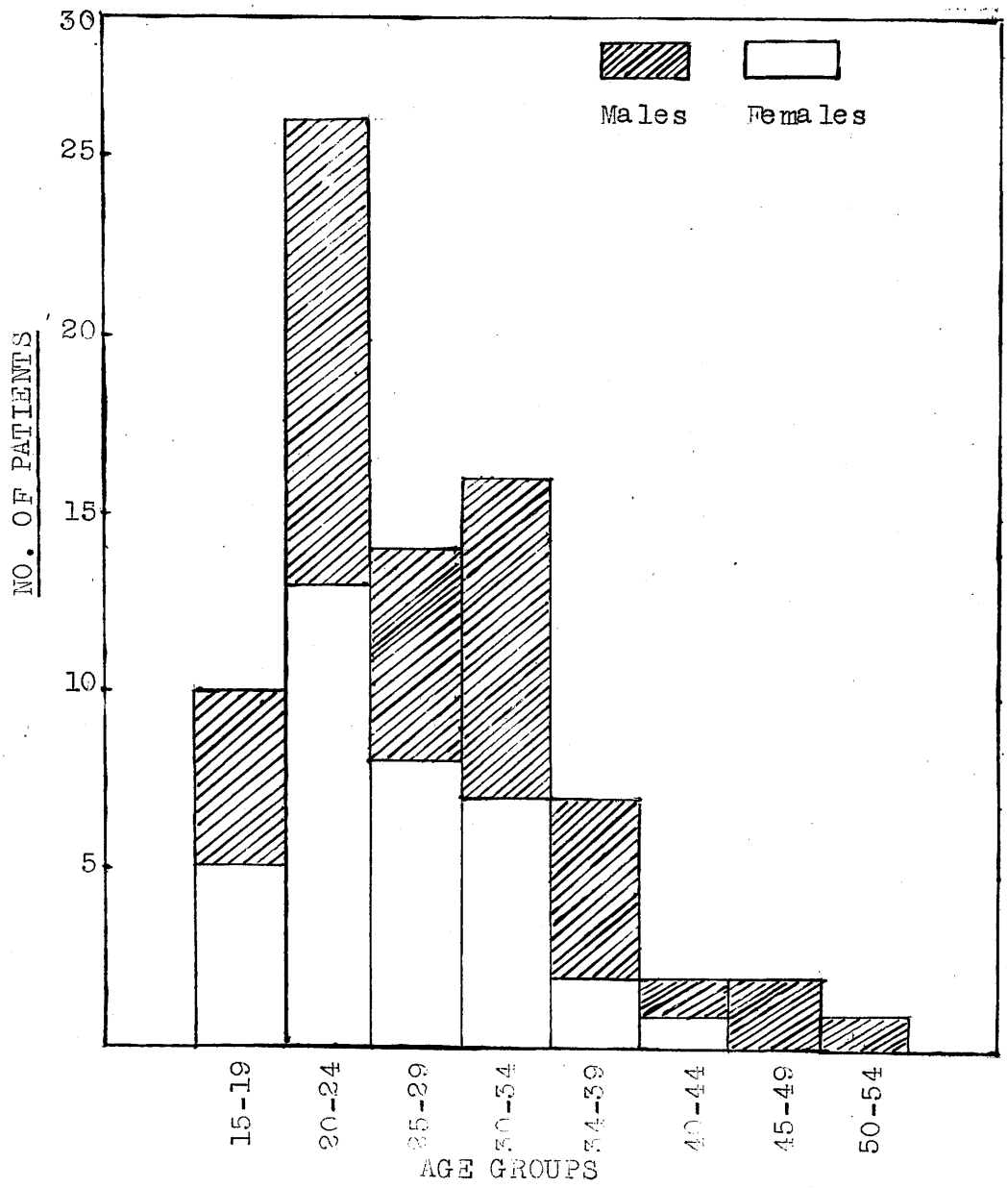


TABLE 6

50 Cases of Unilateral Pneumothorax and Empyema

Age Distribution on Admission

Age Group	Males	Females	Total	%
15-19	2	3	5	10
20-24	8	5	13	26
25-29	6	4	10	20
30-34	7	4	11	22
35-39	4	2	6	12
40-44	1	1	2	4
45-49	2	0	2	4
50-54	1	0	1	2
Over 54	0	0	0	0
Totals	31	19	50	100

TABLE 7

25 Cases of Unilateral Empyema in Bilateral Pneumothorax

3 Cases of Bilateral Empyema

Age Distribution on Admission

Age Group	Males	Females	Total	%
15-19	3	2	5	17.9
20-24	5 x	8 x	13	46.4
25-29	0	4	4	14.2
30-34	2	3	5	17.9
35-39	1 X	0	1	3.6
40-44	0	0	0	
45-49	0	0	0	
50-54	0	0	0	
Over 54	0	0	0	
Totals	11	17	28	100.0

x Includes two cases of bilateral empyema, one male, the other female.

X Includes one case of bilateral empyema.

Tables 6 and 7 show that in the 50 unilateral A.P. cases which developed empyema , 31 (60%) were males

and 19 (38%) were females.

In the 28 bilateral pneumothorax cases, on the other hand, the exact reverse occurred. Only 11 (39.3%) were males and 17 (60.7%) were females.

Age distribution showed the greatest number in both unilateral and bilateral A.P's. fell into the 20-24 age group, with the age group 30-34 coming second.

81 Empyemata

44 (54.3%) of the empyemata occurred in males and 37 (45.7%) in females.

The right and left sides were affected, as shown in the Table below.

TABLE 8

Showing Side of Chest affected in 81 Empyemata.

	Males		Females	
	Right	Left	Right	Left
Unilateral A.P. and empyema	15	16	7	12
Bilateral A.P. and unilateral empyema	4	5	4	12
Bilateral A.P. and bilateral empyema	2	2	1	1
Total	21	23	12	25

Thus of the 44 empyemata which occurred in males, 21 (47.7%) occurred on the right side, and 23 (52.3%) on the left.

Of 37 empyemata in females, 12(32.4%) occurred on the right side, and 25(67.6%) on the left side.

Both sexes combined showed a frequency of

Right sided empyemata ..... 33 cases (40.7%)

Left sided empyemata ..... 48 cases (59.3%)

Classification of Cases on Admission

Cases were classified on admission and re-classified on induction of pneumothorax according to the Ministry of Health's classification of pulmonary tuberculosis.

TABLE 9

Classification on Admission and on Induction of A.P.

78 Cases

Classification Min. of Health	On Admission		On Induction of A.P.	
	No.	%	No.	%
R.A. 2	5	6.4	1	1.3
R.A. 3	1	1.3	0	0
R.B. 2	56	71.8	60	76.9
R.B. 3	16	20.5	17	21.8
Total	78	100.0	78	100.0

All five cases which were classed as R.A. on admission became R.B. some time during treatment, four within a few weeks from admission.

TABLE 10 - 50 Cases

Classification of 50 Unilateral A.P. and Empyema Cases on Admission

Classification Min. of Health	On Admission		On Induction of A.P.	
	No.	%	No.	%
R.A.2	5	10	1	2
R.A.3	1	2	0	0
R.B.2	36	72	40	80
R.B.3	8	16	9	18
Total	50	100	50	100

TABLE 11 - 28 Cases

Classification of 28 Cases of Bilateral Pneumothorax. 25 Cases developed Unilateral Empyema: 3 Cases Bilateral Empyema.

Classification Min. of Health	On Admission		On Induction of A.P.	
	No.	%	No.	%
R.A.	0	0	0	0
R.B.2	20	71.4	20	71.4
R.B.3	8	28.6	8	28.6
Total	28	100.0	28	100.0

One of the bilateral pneumothorax cases which

developed bilateral empyema was in category R.B.2. The other two similar cases were in category R.B.3.

FAMILY HISTORY

Thirty-five of the 78 patients (44.9%) gave a family history of pulmonary tuberculosis. The remainder, forty-three patients (55.1%) had no previous positive family history.

Contacts -

Of the total number of seventy-eight cases, nineteen (24.3%) were contacts of other cases.

Length of stay in Sanatorium -

The longest stay of a patient after empyema developed was 1,428 days. The average stay was 541 days.

PART 2

ETIOLOGY

1. Preceding Serous Effusion

Rafferty(1944) states that empyema occurs almost invariably after many weeks or months of serous effusion. Change from serous effusion to frank pus occurs at a varying interval according to the severity of the pleural infection,(Keers and Rigden,1945).

Preliminary effusion in this series was as shown in Table 12 below.

TABLE 12 81 Empyemata

	No. of A.Ps	%
Preceded by clear effusion	56	69.1
Preceded by haemothorax	3	3.7
Pus on occasion of first aspiration	22	27.2
Total	81	100.0

Of the fifty-six cases preceded by serous effusion, a total of twenty-three(41.1%) became turbid by the time of the second aspiration and remained turbid throughout the course of treatment. The remaining thirty-three cases (58.9%) progressed to frank pus.

The interval which elapsed between the first aspiration of serous fluid and the first aspiration of pus in these thirty-three cases is shown in Table 13.

TABLE 13

33 Cases of Serous Effusion.

Interval in weeks from aspiration of serous fluid to aspiration of pus.

Interval Weeks	No. of Cases	%
2 - 4	7	21.3
5 - 8	9	27.3
9 - 12	4	12.1
13 - 16	5	15.1
17 - 20	1	3.0
21 - 24	3	9.1
25 - 28	1	3.0
29 - 32	0	0
33 - 36	1	3.0
Not known	2	6.1
Total	33	100.0

Of the 33 cases in whom serous effusion progressed to pus, a total of 16 (48.6%) had developed pus within 8 weeks and 25 cases (75.8%) within 16 weeks from the occasion of the initial aspiration of serous fluid.

In two cases the interval was not known. These cases had had serous effusion while in the Sanatorium, had been discharged with a dry pleural

space, but were re-admitted after intervals of six months and 7½ months respectively with pus in the pneumothorax space.

Three Haemothorax Cases.

Three cases developed haemothorax after adhesion section. Pus developed in six, eleven and eighteen weeks respectively from the time of haemothorax.

2. Infection.

The tubercle bacillus was demonstrated in the fluid aspirated from all cases in this series. This finding established the principal etiological cause of infection.

Culture of aspirated material was routine procedure after direct smear examination, whether the latter was positive or not. Guinea pig inoculation was used in two cases in which culture was negative.

Demonstration of the tubercle bacillus in the eighty-one cases was as shown in Table 14.

TABLE 14 - 81 Cases

Demonstration of Tubercle Bacilli in Pleural Exudate.

	No.	%
Pleural exudate positive on direct smear and culture	57	70.4
Negative direct smear, positive on culture	22	27.2
Negative culture and smear but positive on guinea-pig inoculation	2	2.4
Total	81	100.0

Secondary Pyogenic Infection -

Thirty-four patients (43.6%) had their empyemata secondarily infected. One patient with bilateral empyemata had both sides secondarily infected. Thus thirty-five (43.2%) of 81 empyemata fall into the pyogenically infected Group B.

Secondary Infecting Organisms -

Twenty-nine (82.8%) of the 35 Group B empyemata were infected with Staphylococcus Aureus and Staphylococcus Albus.

Four cases (11.4%) became infected with both staphylococci and streptococci some time during treatment. One case (2.4%) became infected with staphylococci, streptococci and pneumococci, and one other case withB. Proteus.

TABLE 15

Causes of Pyogenic Infection.

The causes of secondary infection were as follows :-

	No. of Cases of Pneumothorax	%
Broncho-pleural fistulae	18	51.4
Infected during treatment in Sanatorium aspiration	15	42.9
Infected during treatment as out-patients and re-admitted with secondary infection	2	5.7
Total	35	100.0

Pleuro-cutaneous Sinuses -

Twenty-two patients got pleuro-cutaneous sinuses, and one patient developed tuberculous nodules in the skin as the result of treatment. All 22 cases of pleuro-cutaneous sinus, representing 27.2% of the empyemata, became secondarily infected. Further details of the treatment which resulted in these patients developing sinuses, and of their condition on discharge, will be given in the section devoted to Treatment and Results.

3. Classification of Disease on Admission.

It was decided to classify the types of disease in the present series of patients into two groups,

apart from the classification given on page 15, which is that of the Ministry of Health.

These two groups were:-

1. Classification according to that accepted by the National Tuberculosis Association of America as modified by Salkin and Cadden (1941).

2. Classification as accurately as radiological and clinical findings would allow into the four groups suggested by Rafferty (1944) as being unsuitable for pneumothorax treatment.

Difficulty was encountered in classifying cases into Rafferty's Group IV, that is, patients with tuberculosis of a major bronchus, for the reason that routine bronchoscopy was not practised in the Sanatorium during the period under review. Instead, it was decided to assume that patients in whom complete atelectasis of the lung occurred during pneumothorax treatment must have been suffering from severe endobronchial tuberculosis at the time the pneumothorax was induced. This assumption is based on experience of cases in subsequent years, for in every case in which complete atelectasis occurred, endobronchial disease of greater or lesser severity, but always affecting a major bronchus, was found at bronchoscopy.

Table 16 shows the classification according to Salkin and Cadden (1941). No case came into the Group I category of minimal disease.

TABLE 16 78 Cases

Classification (Salkin and Cadden)

Group No.	Total Classification	Sub-Group No.	One lung disease	Other lung disease	No. of Cases	%
II	Moderate disease	5	mod.	min.	9	11.5
		6	mod.	mod.	15	19.2
III	Far advanced disease	7	mod.	min.	3	3.8
		8	mod.	mod.	14	17.9
		9	far	clear	2	2.5
		10	far	min.	8	1o.5
		11	far	mod	22	28.2
		12	far	far	5	6.4
				Totals	78	100.0

As previously stated , the total number of 78 patients involved 81 empyemata, made up as follows:-

	No. of Cases
Unilateral pneumothorax and empyema.	50
Bilateral pneumothorax, unilateral empyema	25
Bilateral pneumothorax and empyema	3
Total	78

Classifying these three Groups separately according to the class of disease on admission results in the findings shown in Table 17.

TABLE 17

Classification of Disease at Induction of Pneumothorax
Salkin and Cadden's Classification

	Moderately Advanced Disease		Far Advanced Disease		Total	%
	No. of Cases	%	No. of Cases	%		
Unilateral pneumothorax and empyema	16	20.5	34	43.6	50	64.1
Bilateral pneumothorax unilateral empyema	8	10.3	17	21.8	25	32.1
Bilateral pneumothorax and empyema	0	0	3	3.8	3	3.8
Totals	24	30.8	54	69.2	78	100.0

Of the 50 unilateral pneumothorax cases, 34 (68%) were in the far advanced class of disease at induction. Of the 25 bilateral pneumothorax cases which developed unilateral empyema, 17 (68%) were in the

far advanced category . All three cases which developed bilateral empyema came into the far advanced category of disease at induction of pneumothorax.

Tables 16 and 17 show that only 24(30.7%) of cases were in the "moderate" class of disease on admission. On the other hand, 54 (69.3%) were in the "far advanced" category on admission.

Only two cases (2.5%) had a contra-lateral lung that could be classified as clear, and in these two cases the disease in the homolateral lung was in an advanced state.

As already stated,all pneumothoraces were induced in from two to four weeks from the time of admission and it is reasonable to assume that the classification of disease at the time of induction of pneumothorax was similar to that at the time of admission.

In view of the fact that the above (Salkin and Cadden) classification gives no indication of the pathology of the cases,it was decided to classify the cases clinically and radiollogically according to the suggestion of Rafferty (1944). This classification is shown in Table 18 on the next page.

TABLE 18 75 Cases

(Classified according to Rafferty)

Group	Type of Disease	No. of Patients	%
1	Pneumonic or acute exudative	28	35.9
2	Large apical cavity	19	24.4
3	Extensive unilateral cavitation	16	2o.5
4	Endobronchial disease of a major bronchus	12	6.4
	Total	75	87.2

Three cases (12.8%) did not come into any of the above categories. Two of these three cases had lower lobe cavitation , and one dorsal lobe cavitation.

From Table 18 it can be seen that 63 (equivalent to slightly more than 80% of the 78 cases) had either acute exudative disease or advanced cavitation.

4. Erythrocyte Sedimentation Rate.

The erythrocyte sedimentation rate, as understood in this Thesis, is the two-hourly reading in millimetres (Westergren). It has been the practice in the Cheshire Joint Sanatorium to estimate the erythrocyte sedimentation rate (e.s.r.) at one hour and two hour intervals, the second hour reading being

the one used for practical purposes.

E.S.R. at Time of Induction of Pneumothorax.

Experience over a number of years has suggested that effusion in artificial pneumothorax has occurred more frequently in patients in whom the e.s.r. was 40 m.m. or more (2hours Westergren) at the time of induction of the pneumothorax.

Table 19 shows the E.S.Rs. at the time of induction of 81 pneumothoraces which developed empyemata.

TABLE 19

81 Pneumothoraces: E.S.R.(2 hour Westergren) at time of Induction of Pneumothorax

E.S.R. m.m.		Number of A.Ps.	% of A.P.s.
10 - 20		2	2.5
21 - 30		3	3.7
31 - 40		7	8.6
41 - 50		18	22.2
51 - 60		13	16.1
61 - 70		7	8.6
71 - 80		15	18.5
81 - 90		8	9.9
91 -100		6	7.4
Over100		2	2.5
Total		81	100.0

It can be seen from the above Table that 69 (85.2%) of the pneumothoraces were induced when the sedimentation rate was more rapid than 40 m.m. in 2 hours (W.).

Further investigation of these 69 cases was made, firstly into the time interval in weeks which elapsed beween the induction of pneumothorax and the onset of effusion , and secondly, to ascertain the interval between the appearance of effusion and its conversion to empyema. This is shown in Table 20

TABLE 20

69 Pneumothoraces induced when E. S. R. was over 40 m. m. (W.)

Average Interval in Weeks from Induction till Effusion and from Effusion till Empyema

ES. R. Group	No. of A. Ps.	Average time from induction of A. P. till effusion Weeks	Average interval till effusion converted to empyema Weeks
41 - 50	18	17.5	8.6
51 - 60	13	14.2	6.0
61 - 70	7	13.7	5.4
71 - 80	15	13.2	4.1
81 - 90	8	11.0	Purulent from first aspiration.
91 -100	6	4.1	
Over100	2	2.5	
Total	69		

It can be seen from Table 20 that the higher the sedimentation rate at induction of pneumothorax the shorter the intervals bewteen onset of effusion and consequent empyema.

Although only sixteen empyemata are shown in Table 20 as having been purulent from the first aspiration there were altogether twenty-two (27.2%) of the eighty one empyemata purulent from the start.

Duration of Disease at Induction of Pneumothorax.

Hayes(1927) has suggested that there is a higher proportion of empyemata among those patients in whom the disease has been of short duration prior to induction of pneumothorax.

Duration of symptoms prior to admission for the 78 patients in this series is shown in Table 21.

TABLE 21 78 Cases

Duration of Symptoms prior to Admission

Duration of Symptoms Months	No. of Patients	%
1 - 6	37	47.4
7--12	24	30.8
13 -18	9	11.5
19 -24	4	5.1
25 -36	2	2.6
37- 48	2	2.6
Total	78	100.0

From Table 21 it is seen that 61 patients (78%) had symptoms of a year's duration or less. All pneumothoraces were induced within an average period of 2.7 weeks from the time of admission , which does not materially alter the position as far as the acuteness or otherwise of disease at the times of admission and of induction of the pneumothorax is concerned.

5. Type of Collapse after adhesion section.

In this series cases were divided into three classes according to the type of collapse:-

1. Satisfactory.
2. Incomplete.
3. Ineffective.

Satisfactory collapse means a pneumothorax with complete relaxation of the apex, with no adhesions to the lateral chest wall and no adhesions to the upper mediastinum above the level of the clavicle.

Incomplete collapse includes all cases with the lung apex adherent to the cupola, or with adhesions to the mediastinum at the apico-mediastinal angle.

Ineffective collapse includes those cases in whom there was massive adherence of the apex to the dome of the chest, and all cases in whom there were inoperable adhesions to the lateral chest wall, irrespective of the apical relaxation. Before operation none of the cases had a collapse that could be considered as satisfactory.

The type of collapse in each of the 81 pneumothoraces is shown in Table 22 with the Ministry of Health classification on admission.

TABLE 22

81 Pneumothoraces. Type of Collapse after Adhesion Section.

Type of Collapse	Classification Ministry of Health						Totals	
	RA2		RB2		RB3		No.	%
	No.	%	No.	%	No.	%		
Satis-factory	0		22	27.2	4	4.9	26	32.1
Incom-plete	1	1.2	24	29.6	5	6.2	30	37.0
In-effective	0		17	21.0	8	9.9	25	30.9
Total	1	1.2	63	77.8	17	21.0	81	100.0

Table 22 shows that fifty-five (67.9%) of the total number of 81 pneumothoraces fell into either the incomplete or ineffective class of collapse after adhesion section. Not all the eighty-one pneumothoraces, however, were operated upon. Five cases, all of which came into the "ineffective" class of collapse were abandoned after thoracoscopy (no adhesions being divided). Two other cases also classed as having "ineffective" collapse had their pneumothoraces abandoned before thoracoscopy because empyema was already present.

6. Atelectasis.

Complete atelectasis of the lung after adhesion section developed in twelve (16.2%) of the seventy-four pneumothoraces submitted to adhesion section.

The relationship of atelectasis to the development of empyema in pneumothorax will be dealt with in Section 4 of this Thesis, in Discussion on Etiology of Empyema in the eighty-one cases under review.

Table 23 gives data on these twelve cases. This Table shows one outstanding feature, and that is the dissimilarity of all the cases except, perhaps, Nos. 4 and 10. These two cases had tuberculous pleura, and had satisfactory collapse with failure of the cavity to close. Both cases developed broncho-pleural fistulae.

None of the twelve cases was submitted to bronchoscopy.

TABLE 23. 12 Cases

Complete Atelectasis

Case No.	State of pleura at thoracoscopy	Atelect. before cautery of Adhesions	Fluid present before Atel. developed	Type of collapse after cautery of Adhesions	Cavity closed after cautery of Adhesions	Interval from cautery till Atelect. Wks.	Interval from complete Atelect till empyema Wks.	Duration of Atelectasis Wks.	Bronchopleural fistula developed
1	Healthy	Yes, complete	No	Incomplete	No	Present before cautery	6	37	Yes
2	"	No.	No.	"	No	7	1	Present on discharge	No
3	Unhealthy	No	No	"	Yes	1	9	28	No
4	Unhealthy tubercles	No	No	Satisf.	No	6	1½	21	Yes
5	Healthy	No	No	Incomplete	Yes	4	11	30	No
6	Unhealthy	No	Yes	Satisf.	Yes	1	12	20	No
7	Unhealthy tubercles	Yes, upper lobe	Yes	Incomplete	Yes	5	2	10	No
8	Healthy	Yes, upper lobe	No	"	No	3 days	4 days	15	Yes
9	Healthy	Yes, upper lobe	No	Satisf.	No	1	1	16	Yes
10	Unhealthy tubercles	No	No	"	No	2	1	17	Yes
11	Healthy	No	Yes	"	No	30	2	36	No
12	"	No	Yes	Incomplete	No	8	3	44	No

7. Extent of Adhesions.

Adhesion section by closed pneumolysis was performed in seventy-four (91.4%) of the eighty-one pneumothoraces. One case, after two unsuccessful sessions of closed pneumolysis, was subjected to open pneumolysis. His collapse was still ineffective after open operation. Table 24 shows the number of pneumothoraces operated upon.

TABLE 24

74 Cases of Closed Pneumolysis

	Unilateral pneumothorax		Bilateral pneumothorax		Total	%
	No. of Cases	%	No. of Cases	%		
Adhesion section	45	55.6	29	35.8	74	91.4
Thoracoscopy only (no adhesions divided)	4	5.0	1	1.2	5	6.2
Abandoned before thoracoscopy	1	1.2	1	1.2	2	2.4
Total	50	61.8	31	38.2	81	100.0

The extent of the adhesions existing after pneumothorax has been induced is difficult to assess, but may be considered as directly related to the time spent on actual cauterization of adhesions. Unfortunately, the records of time spent on actual

adhesion section were recorded in only forty-five (60.8%) of the seventy-four cases operated upon.

Of these forty-five cases, twenty-six (57.8%) referred to cases of unilateral pneumothorax, and seventeen (37.8%) to cases of bilateral pneumothorax with unilateral empyema, and two (4.4%) to one case of bilateral pneumothorax and empyema.

Tables 25, 26 and 27 show the times, in minutes, spent on adhesion section and the average interval in weeks from adhesion section till the onset of empyema.

TABLE 25. 26 Cases.

Adhesion Section: Unilateral Pneumothoraces.

Time in minutes. Single Sessions.	No. of Cases.	Average interval till onset of empyema. Weeks
1. Up to 30	3	20
2 31 - 45	8	15
3 46 - 60	7	7
4 61 - 75	3	4.3
5 76 - 90	2	2.5
6 Over 90	0	0
Double Sessions.		
1. 45 and 25 then open pneumolysis	1	Haemothorax within 24 hours: pus in 6 weeks.
2. 20 and 15	1	20
3. 20 and 30	1	11
Total	26	

The double sessions were at intervals of 6.5 weeks.

TABLE 26. 17 Cases

Bilateral Pneumothoraces - Unilateral Empyema.

Single Sessions Minutes	No. of Cases of A.P.	Average interval till empyema. Weeks
Up to 30	8	11
31 - 45	3	9
46 - 60	3	6
61 - 75	0	0
76 - 90	0	0
Exactly 120	1	1
Double Sessions Minutes		
30 and 40	1	Re-admitted in 26 weeks with empyema
45 and 5	1	15
	Total 17	

TABLE 27

Bilateral Pneumothorax and Empyema

This case had a single session performed on each side.

	Length of Session. Minutes	Interval till empyema. Weeks
Left side	45	2
Right side induced 3 months after left	10	5

The figures in the above Tables would suggest that the longer the time spent on cauterization of adhesions (inferring that the adhesions were extensive), the shorter the interval until empyema supervened.

8. Fluid before Adhesion Section.

Of the 74 cases operated on, only three (4%) had sufficient fluid to require aspiration before operation. Two other cases had fluid to the 4th costal cartilage, but this absorbed, and at the time of operation only a small diaphragmatic puddle remained.

The interval that elapsed in these five cases, between operation on adhesions and onset of empyema, is shown below.

Case No.	Extent of Effusion before Adhesion Section.	Interval from adhesion section till onset of empyema. Weeks.
1.	Effusion to 4th costal cartilage: not aspirated: absorbed to a supra diaphragmatic puddle by operation	4
2.	Effusion to 2nd costal cartilage. Aspirated 3 times before operation.	7
3.	Effusion to 1st costal cartilage: aspirated 3 times before operation.	9

Case No.	Extent of Effudion before Adhesion Section.	Interval from adhesion section till onset of empyema. Weeks
4.	Effusion to 2nd costal cartilage: aspirated twice before operation.	13
5.	Effusion to 4th costal cartilage: not aspirated but absorbed before operation	36

Of the remaining sixty-nine cases submitted to adhesion section, forty (58%) had only a diaphragmatic puddle of fluid in the period from induction till adhesion section. In thirty-seven cases which developed empyema within a period of weeks from adhesion section, the average interval from adhesion section till onset of empyema was 10.1 weeks. Twenty-nine cases (42 %) had no fluid before operation, and in twenty-eight in which empyema developed within a period of weeks from adhesion section, the average interval from adhesion section till onset of empyema was 11.0 weeks.

Apparently the presence of a diaphragmatic puddle of fluid in the interval between induction of pneumothorax and cauterizing of adhesions does not materially shorten the interval till empyema develops in cases which develop empyema.

9. Positive Pressures in Pneumothorax.

Twenty-four (29.6%) of the 81 pneumothoraces in which empyema developed had positive pressures used to maintain the pneumothorax prior to adhesion section.

Thirteen (54.1%) of the cases in whom positive pressures were used were in Salkin and Cadden's (1941) classification of far advanced disease. The remaining eleven cases (45.9%) were in the moderately advanced disease class, suggesting that in the cases in whom positive pressures had to be used, the extensive nature of the disease had resulted in proportionately extensive adhesions.

In sixteen of the twenty-four cases where positive pressures were used, the time spent on cauterization of adhesions was recorded. In the other eight cases times were not recorded. The time in minutes spent cauterizing adhesions in the sixteen cases is shown in Table 28.

The time spent on cauterization of adhesions in these cases would suggest that the adhesions must have been fairly extensive, and that positive pressures had to be used to maintain the collapse.

TABLE 28 16 Cases.

Positive Pressure Pneumothoraces

Time spent on Cauterization of adhesions in 16 positive pressure pneumothoraces.	No. of Cases.
Minutes:	
Single Sessions.	
Up to 30 minutes	3
31 - 45	6
46 - 60	3
61 - 75	1
Double Sessions	
20 and 15 minutes	1
30 and 40 "	1
40 and 25 "	1
Total.	16

10. Cavity closure after adhesion section

The type of collapse and state of cavity closure will be dealt with more fully in a later part of the Section on Etiology, but meantime the degree of cavity closure and type of collapse obtained in the 74 cases submitted to adhesion section are as shown in Table 29 below.

TABLE 29. 74 Cases

Cavity Closure after Adhesion Section

Type of Collapse.	Cavity Closed.		Cavity not closed		Total	%
	No.	%	No.	%		
Satisfactory	8	30.8	18	69.2	26	35.1
Incomplete	7	23.3	23	76.7	30	40.5
Ineffective	0	-	18	100.0	18	24.4
Total	15	20.3	59	79.7	74	100.0

Table 29 shows that in fifty-nine (79.7%) of the seventy-four cases submitted to operation, in almost four-fifths, irrespective of the type of collapse obtained, failure to achieve cavity closure resulted. Only one-fifth of the cases had their cavities closed after adhesion section, and in just under half of these cases, the collapse was unsatisfactory.

If one adds to the fifty-nine cases shown in Table 29, in the "cavity not closed" class, the seven additional cases of ineffective collapse on whom no operation was performed and cavity closure was not obtained, the number of pneumothoraces falling into this class rises to sixty-six, representing 85.2% of the total number of eighty-one pneumothoraces.

11. State of Pleura at Thoracoscopy.

The state of the pleura as seen at thoracoscopy was recorded in seventy (86.4%) of the pneumothoraces. In nine cases (11.1%) this information was not recorded, and in two cases (2.5%), the state of the pleura could not be ascertained owing to the pneumothorax being abandoned before thoracoscopy.

The condition of the pleura in those cases in which it was recorded is shown in Table 30 below. The term "unhealthy" indicates a pleura on which actual tubercles were seen, or which was either white and sodden, or angry red in appearance.

TABLE 30. 70 Cases

State of Pleura in 70 Pneumothoraces as seen at Thoracoscopy

	Healthy		Unhealthy		Total	
	No.	%	No.	%	No.	%
Unilateral pneumothorax and empyema	21		23		44	
Bilateral pneumothorax and unilateral empyema	5		17		22	
Bilateral empyema	3		1		4	
Total	29	41.4	41	58.6	70	100.0

Six of the 41 cases noted as having unhealthy pleura had, in fact, numerous tubercles on the visceral and parietal pleurae.

Table 30 shows that nearly 59% of the cases in whom the state of the pleura was known were seen at thoracoscopy to be unhealthy.

12. Broncho Pleural Fistula

Known broncho-pleural fistula occurred in twenty-eight (34.6%) of the eighty-one pneumothoraces in which empyema developed.

Fifteen fistulae (53.6%) occurred in the fifty cases of unilateral pneumothorax. Twelve (42.8%) occurred on the homolateral side in the twenty-five cases of bilateral pneumothorax, while one broncho-pleural fistula (3.6%) occurred in the six pneumothoraces involved in the three patients who developed bilateral empyema.

Secondary infection in cases of Broncho-pleural fistula.

Eighteen (64.3%) of the twenty-eight cases of broncho-pleural fistula produced immediate secondary infection of the pneumothorax space while simultaneously causing tuberculous empyema. Thus of the total of thirty-five empyemata which became secondarily infected, eighteen (51.4%) owed their secondary infection to broncho-pleural fistulae.

Type of Collapse and State of Cavity Closure in cases of Broncho-pleural fistula.

Table 31 shows the type of collapse after adhesion section in twenty-seven cases of broncho-pleural fistula. The remaining case was not operated upon.

TABLE 31 27 Cases

Broncho-pleural Fistulae; Type of Collapse and State of Cavity Closure

	Cavity Closed		Cavity not Closed			
	No.	%	No.	%	Total	%
Type of Collapse						
Satisfactory	1	3.7	8	29.6	9	33.3
Incomplete	0	0	10	37.1	10	37.1
Ineffective	0	0	8	29.6	8	29.6
Totals	1	3.7	26	96.3	27	100.0

Table 31 shows that twenty-six of the fistulae equivalent to 96% , occurred in cases of collapse in which cavity closure was not obtained. Nine cases of fistula (32.1% of the total number of fistulae), occurred in pneumothoraces classed as satisfactorily collapsed after adhesion section, but in only one of these collapses was cavity closure obtained. Eighteen fistulae occurred in cases either incompletely or ineffectively collapsed, but in none of these cases was cavity closure obtained.

One other case of fistula occurred in a pneumothorax with ineffective collapse. No adhesions were divided

when it was found at thoracoscopy that they were very extensive. Adding this case to the eight already noted as occurring in cases of ineffective collapse, it raises the total number of fistulae in this class of collapse to nine, equivalent to 32.1% of the total number of twenty-eight broncho-pleural fistulae.

Classification of Disease at Induction of Pneumothorax in cases of Broncho-Pleural Fistula.

The twenty-eight cases which later developed broncho-pleural fistula were classified according to the type of disease present at induction of pneumothorax (Salkin and Cadden's classification). Table 32 shows the classification.

TABLE 32. 28 Cases

Type of Disease.	No. of Cases	%
Moderately advanced disease	9	32
Far advanced disease	19	68
Total	28	100

Table 32 shows that a little over two-thirds of the cases which developed broncho-pleuralfistula were in the "far advanced" class of disease at induction of pneumothorax.

State of Pleura at Thoracoscopy

In the twenty-eight cases of broncho-pleural fistula, the pleura was found to be unhealthy in twelve (42.9%), healthy in twelve (42.9%), and was not recorded in four cases (14.2%).

Causes of Broncho-Pleural Fistula and Interval from Adhesion Section

Within one week of adhesion section :-

Nine cases of fistula occurred within one week of adhesion section.

Three cases were traumatic at operation, spontaneous pneumothorax or fistula occurring at intervals of 12 hours, 48 hours and 72 hours respectively after operation.

Four cases suffered rupture of tension cavities , two cases occurring three days after operation and two on the seventh day after operation. In one of these cases the collapse was apparently satisfactory , in two it was incomplete and in one ineffective . In none was cavity closure obtained; on the contrary, all these cases had ballooning tension cavities.

Two cases suffered fistulae through unhealthy

tuberculous pleurae on the seventh day following operation. In neither case was cavity closure obtained although collapse was satisfactory in one case but incomplete in the other. One of these cases was noted at thoracoscopy to have numerous tubercles on the visceral pleura, whilst the other had a dull white sodden pleura with areas of caseation beneath.

Of the remaining nineteen cases of broncho-pleural fistula, eighteen occurred at intervals following adhesion section as shown in Table 33.

TABLE 33

Eighteen Cases of Broncho-pleural Fistula: Interval in weeks following adhesion section till occurrence of Fistula and apparent Causes of Fistulae.

Case No.	Interval from operation till fistula. Weeks	Cause of Fistula.
1	2	Ruptured apical cavity.
2	2	Ruptured upper lobe cavity.
3	3	Rupture through tuberculous pleura
4	3	Rupture of upper lobe cavity
5	4	Ruptured apical cavity
6	5	Ruptured upper lobe cavity
7	7	Ruptured apical cavity.

TABLE 33 (Continued)

Case No.	Interval from operation till fistula. Weeks	Cause of Fistula.
8	7½	Rupture of upper lobe cavity.
9	10	Rupture of dorsal lobe cavity.
10	10	Rupture of upper lobe cavity.
11	14	Rupture of apical cavity.
12	16	Rupture through pleura studded with tubercles.
13	18	Rupture of apical cavity.
14	20)	" " " "
15	20)	
16	24	" " " "
17	40	Rupture of lower lobe cavity.
18	68	Rupture of dorsal lobe cavity.

One case on which no operation was performed and in whom pneumothorax was induced while a tuberculous pneumonia was present suffered broncho-pleural fistula twelve weeks after induction of the pneumothorax and four weeks from thoracoscopy. In this case the collapse had been induced and maintained by positive intra pleural pressures in the presence of tuberculous pneumonia and very extensive plaural adhesions.

Of the twenty-seven cases submitted to pneumolysis, the causes of broncho-pleural fistula were as follows:-

1. Three were due to trauma at operation.

2. Twenty were due to rupture of cavities. Seven of these cases occurred in apparently satisfactorily collapsed cases, but in none was cavity closure obtained. The remaining thirteen occurred in cases either incompletely or ineffectively collapsed. One case of ruptured cavity resulted after 4 months treatment by oleothorax.

3. Four cases occurred from rupture of tuberculous foci through diseased pleurae. In one of these cases collapse was complete and the cavity apparently closed, but spontaneous pneumothorax occurred 16 weeks after operation. In this case the pleura was seen at thoracoscopy to be studded with tubercles. In the other three cases cavity closure was not obtained and the collapses were either incomplete or ineffective.

In three cases which suffered broncho-pleural fistula, diaphragmatic paralysis by phrenic crush was performed to attempt to close a ballooning tension cavity. In one other case phrenic crush, supplemented by pneumo-peritoneum was done, but this also failed to prevent the cavity from enlarging and rupturing.

Atelectasis in Cases of Broncho-pleural Fistula.

Broncho-pleural fistula was preceded by complete atelectasis of the lung in five cases (18%)

and lobar atelectasis in two cases (7.1%) of the total number of twenty-eight cases in which fistula occurred.

13. Relationship of Adhesion Section to Onset of Empyema.

It has been shown in the preceding pages that twenty-eight of the total of eighty-one empyemata were due to known broncho-pleural fistulae. Twenty-seven of these cases were submitted to operation. After deducting these twenty-seven cases from the total of seventy-four on whom adhesion section was performed, forty-seven cases remain for consideration.

Six empyemata, including one case of bilateral empyema, did not develop till between 1 and 3½ years after adhesion section. It is unlikely that operation was associated with the subsequent development of empyema in these cases, although Goorwitch (1943) quotes Smart as stating that empyema occurring within one month to two years after adhesion section may possibly be related to the operation. The six cases mentioned above will be considered later. This leaves forty-one cases of empyema for consideration now in relation to adhesion section.

Table 34 shows the time interval in weeks between the operation of adhesion section and the subsequent onset of empyema in the forty-one cases mentioned above. For reference, the twenty-seven cases of broncho-pleural fistula are included in Table 34.

TABLE 34. 41 Cases

Interval between Adhesion Section and Onset of Empyema.

Interval in weeks from operation till onset of empyema.	No. of Cases: Causes of empyema to be consid-ered.	No. of Cases: Empyema due to broncho-pleural fistula.	Total
1. Within 1 wk.	4	9	13
2. Between 1 and 2 wks.	4	2	6
3. " 2 and 3 "	0	2	2
4. " 3 and 4 "	1	1	2
5. " 4 and 5 "	1	0	1
6. " 5 and 6 "	2	0	2
7. " 6 and 7 "	2	2	4
8. " 7 and 8 "	2	1	3
9. " 8 and 9 "	1	0	1
10 " 9 and 10 "	3	2	5
11 " 10 and 11 "	3	0	3
12 " 11 and 12 "	1	0	1
Total	24	19	43

TABLE 34 (Continued)

Interval in weeks from operation till onset of empyema.	No. of Cases: Causes of empyema to be consid-ered.	No. of Cases: Empyema due to broncho-pleural fistula.	Total
13. Between 12 and 13wks.	2	0	2
14. " 13 and 14 "	1	1	2
15. " 14 and 15 "	1	0	1
16. " 15 and 16 "	0	1	1
17. " 16 and 17 "	0	0	0
18. " 17 and 18 "	1	1	2
19. " 19 and 20 "	1	2	3
20. At 21 wks.	0	0	0
21. At 24 "	1	1	2
22. At 25 "	1	0	1
23. At 26 "	1	0	1
24. At 28 "	2	0	2
25. At 32 "	2	0	2
26. At 33 "	1	0	1
27. At 36 "	1	0	1
28. At 40 "	2	1	3
29. At 68 "	0	1	1
Total	41	27	68

It was decided arbitrarily to divide cases of empyema not due to known broncho-pleural fistulae into two groups :-

1. Those in which empyema developed within twelve weeks of adhesion section; and

2. Those in which empyema developed after an interval of more than twelve weeks from adhesion section.

Table 34 shows that forty-three (58.1%) of the seventy-four cases submitted to adhesion section developed empyema within twelve weeks of operation. Of these, nineteen (44.2%) were due to broncho-pleural fistula. The remaining twenty-four cases were due to other causes. These cases will be considered in the pages immediately following.

Seventeen cases developed empyema after an interval of between twelve and forty weeks following adhesion section. These cases will be considered after those which occurred within twelve weeks of adhesion section.

Three patients, involving six pneumothoraces who developed bilateral empyema will be considered separately because each of the six pneumothoraces came into different categories both as to interval between adhesion section and onset of empyema and type of collapse resulting after adhesion section. Indication will be given where any of the six empyemas come into the first or second categories mentioned above.

Finally, there will be considered the five pneumothoraces not submitted to adhesion section. Of two other pneumothoraces not submitted to adhesion section, one has been considered already in the cases in which empyema was due to broncho-pleural fistula, while the other will be included in the three cases of bilateral empyema.

Twenty-four cases of Empyema which occurred within twelve weeks of Adhesion Section.

Of these twenty-four cases, two were due directly to adhesion section and four to induction of pneumothorax in unsuitable cases with adhesion section precipitating empyema. Details of these cases are as follows :-

1. Two cases developed massive haemothorax one day and five days respectively after operation. Empyema followed haemorrhage in six weeks and eleven weeks respectively.
2. Two cases developed empyema in four days and seven days respectively after operation. Adhesion section lasted 65 minutes and 80 minutes respectively, suggesting the existence of extensive adhesions. Both cases had tuberculous pneumonia at the time of induction of pneumothorax.
3. Two cases developed empyema within seven days of operation. Both cases had far advanced very active disease at the time of induction of pneumothorax and

both had unhealthy tuberculous pleurae and adhesions.

The remaining eighteen cases in which empyema developed within 12 weeks of adhesion section will now be considered.

These cases were classified as follows, according to:

1. Type of collapse and whether cavity closure resulted after adhesion section.

	No. of Cases.
1. Satisfactory collapse and cavity closure	1
2. Satisfactory collapse and failed cavity closure	2
3. Incomplete collapse and cavity closure	6
4. Incomplete collapse and failed cavity closure	5
5. Ineffective collapse and failed cavity closure	4
	18

2. Type of Disease at Induction of Pneumothorax.

1. According to the Ministry of Health's classification for pulmonary tuberculosis, e.g. RA1, RB2, RB3.

2. According to Salkin & Cadden's modification of the classification adopted by the American Tuberculosis Association (1941) referred to as S. & C. in the Tables.
Sub-groups 5 and 6 refer to moderately advanced disease; sub-groups 7, 8, 9, 10, 11 and 12 refer to far advanced disease, the severity of the disease increasing with the grading numbers.

Satisfactory collapse with apparent cavity closure.

One case only came into this category - a unilateral pneumothorax.

TABLE 35. 1 Case

Case No.	Classification of Disease at induction of pneumothorax.		E.S.R. at induction of pneumothorax m.m. 2 hrs. (West.)	State of Pleura at Thoracoscopy	Interval from induction till adhesion section. Weeks	Interval from adhesion section till empyema. Weeks
	Min. of Health	S. & C.				
1	RB2	10	54	Unhealthy (3 aspirations before operation).	6	9

Remarks -

This case had a massive effusion to the second costal cartilage three weeks after induction of the pneumothorax, which suggests a pleuritis existed before and at the time of adhesion section. The lung disease was apparently far advanced, though not very acute.

Cause of empyema appears to have been operation in the presence of far advanced lung disease and active tuberculous pleuritis.

Satisfactory collapse and failed cavity closure.

Two cases: Case 1 was a unilateral pneumothorax. Case 2 was a bilateral pneumothorax.

TABLE 36. 2 Cases

Case No.	Classification at induction of A.P.		E.S.R. at induction m.m. 2 hrs (W.)	State of pleura at Thoracoscopy	Interval from induction till pneumolysis. Weeks.	Interval from pneumolysis till empyema. Weeks.
	Min. of Health.	S. & C.				
1	RB2	6	34	Healthy	6	8
2	RB2	8	29	Red inflamed fluid	8	8

Remarks -

Case 1 was one of moderate disease and activity at induction. Diaphragmatic paralysis by phrenic crush was done in an attempt to close the cavity. The cause of empyema is not known. It may have been due to:

(1) Adhesion section.

(2) A slow broncho-pleural fistula.
(3) Failure to achieve cavity closure.

Case 2 was one of moderately far advanced relatively inactive disease at induction. Pleura was

red and inflamed and fluid was present at operation, suggesting that a pleuritis existed. The cavity in this case was situated in the left lower lobe and was basal in situation with fluid level inside. Empyema may have been due to adhesion section on a red inflamed pleura or to spread of disease from the patent cavity.

Incomplete collapse and cavity closure.

TABLE 37 6 Cases

Cases Nos. 1, 2, 3 and 4 were unilateral pneumothoraces.
Cases Nos. 5 and 6 were bilateral pneumothoraces.

Case No.	Classification at induction.		E.S.R. at induction of A.P. m.m. 2 hrs. (W.)	State of pleura at thoracoscopy	Interval from induction till pneumolysis. Weeks.	Interval from pneumolysis till empyema. Weeks
	Min. of Health	S & C.				
1	RB2	6	19	Healthy fluid	7	10
2	RB2	5	20	Healthy	10	6
3	RB2	8	30	Unhealthy; white sodden	6	12
4	RB2	7	46	Tubercles 3 aspirations before operation	7	7
5	RB2	6	31	White, dull	8	10
6	RB2	11	38	Angry, red	6	2

Remarks -

Case 1 developed pus by 10 weeks from adhesion section, in spite of moderate disease and moderate activity at induction. Adhesion section occupied 55 minutes. Collapse was incomplete, suspended at the apex. Cause of empyema may have been two-fold: (1) Adhesion section; (2) maintaining unrelaxed collapse of lung with stretching of the remaining adhesions.

Case 2: Moderate disease and moderate activity. Massive effusion occurred in 2 weeks from operation. Positive pressures were used to maintain an incomplete collapse. Apparently this empyema was due to combination of adhesion section and maintaining by positive pressures an incomplete collapse.

Case 3: Moderate disease and moderate activity. Pleura was infected and positive pressures were used to maintain incomplete collapse. Adhesion section took 70 minutes. Cause of empyema was either adhesion section or maintaining incomplete collapse in presence of tuberculous pleura and adhesions, stretched by positive pressures.

Case 4: Moderately far advanced disease; moderate activity. Pleura markedly tuberculous.

Complete atelectasis developed 5 weeks from operation. Cause of empyema apparently was operation on tuberculous pleura and possible spread from atelectatic lung.

Case 5: Moderate disease and moderate activity; pleura white and dull. Complete atelectasis developed 1 week after operation. Adhesion section lasted 50 minutes. Cause of empyema appears to have been a combination of:

1. Operation on unhealthy pleura and adhesions.
2. Spread in atelectatic lung to pleura.
3. Maintaining unrelaxed collapse suspended at the apex.

Case 6: One of far advanced moderately active disease at induction of pneumothorax. Pleura and adhesions red and angry. Empyema in 2 weeks following adhesion section suggests that the cause was adhesion section on an unhealthy inflamed pleura.

Incomplete collapse and failed cavity closure.

TABLE 38. 5 Cases

Four cases (Nos. 1 to 4) were unilateral pneumothoraces. One case (No. 5) was one of bilateral pneumothorax.

Case No.	Classification of Disease at induction of A.P.		E.S.R. at induction of A.P. m.m. 2 hrs. (W.)	State of Pleura at thoracoscopy	Interval from induction till pneumolysis. Weeks.	Interval from pneumolysis till onset of empyema Weeks
	Min. of Health.	S. & C.				
1	RB2	5	38	Red, dusky, sodden.	12	2
2	RB3	11	58	Sodden white fluid	12	4
3	RB2	8	55	Healthy	15	11
4	RA2	5	38	Healthy	7	8
5	RB2	11	89	Tubercles fluid	8	4

Remarks -

Case 1. One of moderate disease and moderate activity at induction. Pleura red, dusky, sodden. Purulent empyema in 2 weeks from operation suggests adhesion section was the cause.

Case 2. One of far advanced fairly active disease at induction. Positive pressures were used to maintain collapse. Effusion to the 4th costal

cartilage existed prior to operation. This would suggest a pleuritis existed before operation. Empyema appears to have been due to a combination of factors such as ;

1. Maintenance of incomplete collapse by positive pressures.
2. Adhesion section on tuberculous pleura.

.....

Case 3. One of moderately advanced disease and moderate activity at induction. Adhesion section occupied 60 minutes. Complete atelectasis developed eight weeks after operation. Empyema appears to have been due to combination of :

1. The presence of endo-bronchial disease and development of atelectasis, which became complete.
2. Extensive adhesion section.
3. Maintenance of incomplete collapse.

Case 4. One of moderately advanced and moderately active disease. Complete atelectasis developed seven weeks after operation. Cause of empyema seems to have been due to the same factors as Case 3 above.

Case 5. One of far advanced active disease at induction. Pleura studded with tubercles. Empyema was due apparently to adhesion section in the presence of an acutely tuberculous pleura.

Ineffective collapse and failed cavity closure.

TABLE 39. 4 Cases.

Four pneumothoraces fell into this category, but case 4 will be omitted as it was one half of a bilateral empyema and will be dealt with later.

Cases Nos. 1 and 2 were unilateral pneumothoraces.

Case No. 3 was one of bilateral pneumothorax.

Case No.	Classification of Disease at induction of A.P.		E.S.R. at induction of A.P. m.m. 2 hrs. (W.)	State of Pleura at thoracoscopy	Interval from induction of A.P. till pneumolysis. Weeks.	Interval from pneumolysis till onset of empyema Weeks.
	Min. of Health.	S. & C.				
1	RB2	8	74	Healthy	8	5
2	RB2	11	80	Not stated	15	10
3	RB2	6	76	Sodden, dark red	11	2

Remarks -

Case 1. Moderately far advanced but acutely active disease at induction of pneumothorax. Phrenic crush and pneumoperitoneum were performed to supplement ineffective collapse.

Causes of empyema combination of factors:

1. Collapse by pneumothorax of acutely active advanced disease in lung.

2. Failure to control disease by pneumothorax or diaphragmatic paralysis and pneumo-peritoneum.

3. Adhesion section.

Case 2: Far advanced active disease at induction of pneumothorax. Collapse maintained by positive pressures for 15 weeks prior to adhesion section. After effusion developed high negative pressures were used in attempts to get the lung to re-expand rapidly. Two apical cavities remained patent despite pneumothorax and diaphragmatic paralysis by phrenic evulsion.

Causes of Empyema :

1 Collapse by pneumothorax of acute actively diseased lung.

2 Maintaining inneffective de-selective collapse with stretching of adhesions by positive intra-pleural pressures and failure to get cavity closure.

3. Possible slow broncho-pleural fistula from the effect of repeated and prolonged use of high negative intra-pleural pressures after aspiration.

Case 3: Moderate but very active disease; pleura dark red and inflamed. Purulent effusion in two weeks from operation on adhesions suggests that empyema in this case was due to adhesion section on unhealthy pleura and adhesions.

Summary of Causes of Empyema in twenty - four cases in which it occurred within 12 weeks of Adhesion Section.

Only twenty - three empyemata are, in fact, included under the above heading; the remaining case is considered with the six pneumothoraces involved in the three patients who developed bilateral empyema.

The principal causes of empyema in these twenty-three cases seem to have been :-

1. Adhesion section alone or very possibly the existence of an unhealthy pleura, rather than the operation alone , irrespective of the type of collapse ,was responsible in twelve , or just over 50% of the cases. If adhesion section were solely to blame in these cases very early effusion would be expected.

2. In ten cases a combination of factors seem to have been responsible for the empyemata. These factors were :-

1. Failure to achieve cavity closure
2. The presence of unhealthy inflamed pleura and adhesion section on such pleura.
3. Maintaining incomplete or ineffective collapse with uncontrolled disease and the stretching of unhealthy adhesions by positive intra-pleural pressures.
4. Complete atelectasis supervening after adhesion section. Complete atelectasis developing also suggests endobronchial disease was present.
5. In one case the cause is not known.

14. Seventeen cases developing empyema between twelve and forty weeks after adhesion section.

It is not suggested that seventeen cases which developed empyema after an interval varying between twelve and forty weeks from the date of adhesion section owed the occurrence of empyema directly to the operation. They are described under that heading as a matter of convenience and to permit of comparison with the previous twenty-four cases which occurred at intervals up to twelve weeks following operation.

These seventeen cases will be classified in similar fashion, that is, according to:

1. Type of collapse and whether cavity closure was obtained or not after adhesion section.

2. According to the type of disease existing at the induction of pneumothorax

classified (1) according to the classification of the Ministry of Health.

(2) According to the classification of the American Tuberculosis Association as modified by Salkin and Cadden.

The type of collapse and state of cavity closure in the seventeen cases now to be considered was as follows:-

		No. of Cases.
1.	Satisfactory collapse; cavity closed	4
2.	Satisfactory collapse; failed cavity closure	5
3.	Incomplete collapse; cavity closed	1
4.	Incomplete collapse; failed cavity closure	4
5.	Ineffective collapse; failed cavity closure	3
		17

Satisfactory collapse and cavity closed.

TABLE 40. 4 cases.

Cases 1, 2 and 3 were unilateral pneumothorax.
Case 4 bilateral pneumothorax.

Case No.	Classification of Disease at induction of A.P.		E.S.R. at induction of A.P. m.m. 2 hrs. (W.)	State of Pleura at thoracoscopy	Interval from induction till pneumolysis Weeks	Interval from pneumolysis till empyema Weeks
	Min. of Health	S. & C.				
1	RB2	8	60	Dusky red fluid 2 aspirations	18	13
2	RB2	10	56	Red, inflamed	6	18
3	RB2	11	57	Red, inflamed	8	24
4	RB2	8	85	Healthy	8	26

Remarks -

Case 1: One of moderately far advanced fairly active disease at induction. Aspiration had to be done twice before operation, suggesting a pleuritis existed then. Complete atelectasis developed one week after operation.

Causes of empyema: Adhesion section on diseased pleura and the effects of complete atelectasis.

Case 2: One of far advanced disease and moderate activity at induction. Haemothorax followed 3 days after operation.

Causes of empyema: Adhesion section and haemothorax.

Case 3: Far advanced active disease at induction. Pleura unhealthy. Adhesion section occupied 55 minutes.

Cause of empyema: Not known - can only be surmised that a pre-existing pleuritis was aggravated by operation.

Case 4: Moderately far advanced but very active disease at induction of pneumothorax.

Empyema in this case must have been due to:

1. Collapse by pneumothorax of a lung affected by acutely active disseminated disease which was unsuitable for treatment by collapse.

2. Spread to pleura despite satisfactory collapse and cavity closure.

Satisfactory collapse - failed cavity closure.

TABLE 41. 5 Cases

Cases Nos. 1 to 3 were unilateral pneumothoraces.

Cases Nos. 4 and 5 were bilateral pneumothoraces.

Case No.	Classification of Disease at induction of A.P.		E.S.R. at induction of A.P. m.m. 2 hrs (W.)	State of Pleura at thoracoscopy	Interval from induction till pneumolysis (Weeks	Interval from pneumolysis till empyema (Weeks)
	Min. of Health	S & C				
1	RB2	9	67	Healthy	8	32
2	RB2	10	36	"	7	33
3	RB2	11	70	Not stated	6	20
4	RB2	6	14	Healthy	8	32
5	RB2	11	93	"	7	28

Remarks -

Case 1 was one of far advanced active disease at induction. Complete atelectasis developed 30 weeks after adhesion section. Empyema followed two weeks later. Phrenic evulsion had been done previously to attempt to close the cavity.

Causes of empyema apparently due to three factors

1. Collapse of acutely diseased lung.
2. Occurrence of complete atelectasis.
3. Failure to achieve cavity closure.

Case 2: One of far advanced but only moderately active disease at induction. Pleura healthy.

Cause of empyema not known : may have been spread to pleura from uncontrolled lung disease.

Case 3: One of far advanced active disease at induction of A. P.

Cause of empyema appears to have been spread from uncontrolled lung disease to pleura.

Case 4: Moderately advanced , moderately active disease at induction. A large peripheral cavity remained patent in an atelectatic upper lobe.

Cause of empyema: Broncho-pleural fistula was not proved but from the radiological appearances after empyema developed this would appear to have been the cause. Spread of disease to the pleura with consequent rupture(slowly)of the peripheral cavity appears to have occurred.

Case 5; Very active widely disseminated disease with multiple cavitation.

Causes of empyema :

1. Collapse of acutely active cavitated lung, unsuitable for pneumothorax.
2. Spread from uncontrolled lung disease to pleura.

Incomplete collapse - cavity closed.

TABLE 42 1 case: Unilateral Pneumothorax.

Case No.	Classification of disease at induction of A.P.		E.S.R. at induction of A.P m.m 2 hrs (W)	State of Pleura at thoracoscopy	Interval from induction till pneumolysis (Weeks)	Interval from pneumolysis till empyema (Weeks)
	Min. of Health	S. & C.				
1	RB2	5	9	Healthy	8	15

Remarks -

Case of very moderately advanced disease and slight activity at induction of pneumothorax. Complete atelectasis developed 4 weeks after adhesion section.

Causes of empyema - combination of two factors:-

1. Maintaining incomplete collapse.
2. Occurrence of complete atelectasis.

Incomplete collapse - failed cavity closure.

TABLE 43. 4 cases

Cases 1 and 2 were unilateral pneumothoraces.

Cases 3 and 4 were bilateral pneumothoraces.

Case No.	Classification of disease at induction of A.P. Min. of Health	S & C	E.S.R. at induction of A.P. m.m. 2 hrs (W.)	State of Pleura at thoracoscopy	Interval from induction till pneumolysis (Weeks)	Interval from pneumolysis till empyema (Weeks)
1	RB2	6	76	Angry, inflamed, all adhesions also	8	28
2	RB2	7	45	Sodden white	6	14
3	RB2	8	28	Angry and sensitive pleura and adhesions	7	36
4	RB3	12	78	Not known: fluid present	12	40

Remarks -

Case 1: Case of moderately advanced disease but acutely active disease at induction of pneumothorax. Pleura and adhesions inflamed and angry. Positive pressures used to maintain collapse. Lobar atelectasis developed 4 weeks after adhesion section.

Causes of empyema: Apparently a combination of the following factors :-

1. Pneumothorax induced in state of acute activity of disease, and failed cavity closure.
2. Positive pressures used to maintain a collapse widely adherent at apex.

Case 2: One of moderately far advanced and moderately active disease at induction. Pleura unhealthy.

Cause of empyema not known ,but may have been due to a combination of the following factors:-

1. Maintaining incomplete collapse.
2. Adhesion section on unhealthy tuberculous pleural adhesions.
3. Uncontrolled lung disease allowing spread to pleura.

Case 3: One of moderately far advanced, relatively inactive disease at induction. Pleura and adhesions angry and inflamed.

Cause of empyema not definitely known but may have been due to

1. Maintaining incomplete collapse.
2. Spread of uncontrolled lung disease to pleura.

Adhesion section was done 36 weeks prior to empyema developing and can reasonably be exonerated from blame.

Case 4: One of far advanced disseminated acutely active disease at induction. Incomplete collapse maintained for three months prior to adhesion section. Fluid present at operation.

Causes of empyema:

1. Collapse of lung in which there was acutely active widespread disease.
2. Maintaining incomplete collapse.
3. Uncontrolled disease allowing spread to pleura.

Ineffective collapse and failed cavity closure

Three empyemata, in fact, fell into the above category, but one is excluded as it occurred in a patient with bilateral empyema. This case will be considered with the bilateral empyemata.

TABLE 44. 2 Cases

Case No.	Classification of disease at induction of A.P.		E.S.R. at induction. m.m. 2 hrs (W.)	State of Pleura at thoracoscopy	Interval from induction till pneumolysis (weeks)	Interval from pneumolysis till empyema (Weeks)
	Min. of Health.	S & C.				
1	RB3	8	5	Angry red	24	40
2	RB2	10	72	lustreless fibrin present	6	13

Remarks -

Case 1: One of moderately far advanced disease and moderate activity at induction. Pleura unhealthy; adhesion section took 75 minutes. Cavity remained open.

Causes of empyema not defintely known but may have been due to a combination of factors such as:-

1. Failure to bring about cavity closure.

2. Maintaining before and after adhesion section an ineffective collapse for 16 months in a case of multiple cavitation, unsuitable for collapse by pneumothorax.

3. Extensive adhesions ; inflamed adhesions existed before and after adhesion section, but the collapse was maintained.

Case 2; One of far advanced active disease; pleura unhealthy.

Causes of empyema - as in Case 1 above with the possible aggravating effect of adhesion section on an unhealthy pleura as an additional factor.

Summary of Causes of Empyema in 17 cases in which it occurred between 12 and 40 weeks from Adhesion Section.

Only sixteen cases are, in fact, included in the above category; the remaining empyema will be considered with the bilateral empyemata.

The principal causes of empyema in these sixteen cases are as follows. It is advisable to state that the causal factors are not tabulated in order of importance.

1. Adhesion section in one case.

2. A combination of factors in fourteen other cases. These were :-

(a) Collapse by pneumothorax of cases unsuitable for treatment by pneumothorax.

(b) Failure to achieve cavity closure with consequent spread of uncontrolled lung disease to the pleura. Broncho-pleural fistula may have occurred in one case from this cause.

(c) Development of complete atelectasis

(d) Extensive adhesion section on unhealthy pleurae and adhesions.

(e) Maintenance of incomplete or ineffective collapse - in some cases by positive intra-pleural pressures.

Bilateral Empyema.

Three patients developed bilateral empyema. Details of the six pneumothoraces involved are given in Table 45.

TABLE 45

3 Cases of Bilateral Empyema

Case No.	Classification of Disease at induction of A.P.		E.S.R. at induction m.m. 2 hrs (W.)	State of Pleura at thoracoscopy	Cavity closed after adhesion section	Interval from induction till pneumolysis (Wks.)	Interval from pneumolysis till empyema (Wks.)
	Min of Health.	S. & C.					
1 (L)	RB3	11	68	not stated	No	7	18
(R)	RB3	11	62	"	No	No operation: abandoned	14 from induction
2 (L)	RB2	8	39	Unhealthy white thick, aspirated before opn.	No,	6	10
(R)	RB2	8	37	Healthy	No	21	20
3 (L)	RB3	12	64	Healthy	No	7	18 mths.
(R)	RB3	12	48	"	No	7	14 mths.

Remarks -

In each case the left (L) pneumothorax was induced first.

Case 1: (L) side - far advanced active disease at induction. Collapse ineffective. Broncho-pleural fistula occurred from rupture of an apical cavity 18 weeks after adhesion section.

(R) side - far advanced active disease at induction of pneumothorax, which was done five-and-a-half months after induction of the (L) A.P. and seven weeks before the left empyema developed. Collapse was ineffective. Thick pus was aspirated 14 weeks after induction. This empyema was due to maintaining an ineffective collapse with stretching and possible tearing of multiple adhesions, and failure to get cavity closure.

Case 2: (L) side - moderately far advanced, moderately active at induction. Pleura unhealthy. Fluid was removed at operation. Collapse ineffective. Cause of empyema: Adhesion section on tuberculous pleura.

(R) side - Moderately far advanced, relatively inactive disease at induction. Pneumothorax induced 3 months after the (L) A.P. and 6 weeks before left empyema appeared. Collapse ineffective - disease and

multiple cavitation uncontrolled.

Causes of empyema:

1. Unsuitable case for treatment by pneumothorax.
2. Spread of uncontrolled disease to pleura.

Case 3: Bilateral far advanced active disease at induction.

(L) - collapse satisfactory but cavities not closed after adhesion section. Effusion appeared one week after operation - cleared after one aspiration. Oleothorax instituted.

(R) - collapse ineffective but maintained by oleothorax. Pure pus was aspirated from both sides on occasion of first aspiration.

Causes of empyema:

On the (L) side - oleothorax was induced after an effusion had occurred. Broncho-pleural fistula from oleothorax appears to have been the cause, but was not proved as the patient never spat up oil or pus mixed with oil.

On the (R) side -

1. Collapse of lung affected by active disease with multiple cavitation.
2. Maintenance of completely ineffective collapse by pneumothorax and oleothorax.

Four cases in whom Empyema did not develop till after discharge from Sanatorium.

Four cases developed empyema after discharge from the Sanatorium, and while attending their respective tuberculosis clinics for pneumothorax refills.

Three patients were re-admitted with empyema of indefinite duration 2 years and 8 months, $3\frac{1}{2}$ years, and $4\frac{1}{2}$ years from the date of adhesion section. One case was not re-admitted, but is known to have developed empyema 2 years and 8 months after operation for adhesion section.

It is not suggested that adhesion section had any bearing on the development of empyema in these cases, but the onset of empyema is dated from operation for the sake of uniformity with the previous cases.

Details of these cases are given in Table 46.

TABLE 46. 4 Cases

Case No.	Classification of disease at induction of pneumothorax.		E.S.R. at induction. m.m. 2 hrs. (W.)	State of Pleura at thoracoscopy	Cavity closed after pneumolysis	Type of collapse after pneumolysis	Interval from pneumolysis till serous effusion (Weeks)
	Min. of Health	S. & C.					
1	RB2	6	38	Healthy	No	Incomplete	Wks. 2 Fluid to 5th costal cart.
2	RB2	6	38	Not stated	No	"	Wk. 5 Fluid to 4th costal cart.
3	RB2	11	91	Unhealthy	Yes	Complete	Wk. 3 Fluid to 4th costal cart.
4	RB2	11	47	Inflamed red	No	"	Nil

Remarks -

Case 1: This patient had only moderate disease with moderate activity at induction. Collapse was incomplete. Sputum positive at discharge.

Cause of empyema -

1. Maintaining incomplete collapse.
2. Failure to achieve cavity closure and conversion of sputum.

Case 2: Similar to Case No. 1.

Case 3: This patient had advanced active disease at induction. Effusion developed after adhesion section, but absorbed. Collapse maintained by oleothorax.

Cause of empyema: Not known - may have been broncho-pleural fistula from effect of oleothorax.

Case 4: Far advanced disease, but moderate activity at induction.

Causes of empyema - Similar to Case No. 1.

Cases of Pneumothorax and Empyema in which No Adhesion Section was done.

Seven cases of pneumothorax were not submitted to adhesion section. Five of these were inspected by thoracoscopy and the adhesions were found to be inoperable. One of these cases developed broncho-pleural fistula and has been considered under cases in that category.

Two cases of pneumothorax were abandoned before it was possible to inspect their adhesions because empyema had already developed. One of these pneumothoraces was in a patient who developed bilateral empyema and has been considered with the bilateral empyemata.

Five cases remain for consideration now.

Four cases of Pneumothorax and Empyema submitted to Thoracoscopy only.

Details of these cases are given in Table 47.

TABLE 47 4 Cases

Case No.	Classification of Disease at Induction of A.P.		E.S.R. at induction m.m. 2 hrs (W.)	State of Pleura at thoracoscopy.	Interval from induction till thoracoscopy (Weeks)	Interval from thoracoscopy till empyema (Weeks)
	Min. of Health	S. & C.				
1	RB2	5	38	Angry red	7	1
2	RB2	5	50	Not stated	12	4
3	RB2	11	88	Unhealthy white, aspirated once.	16	1
4	RB2	10	90	Red and inflamed	8	10

Remarks -

1. All cases had ineffective collapse.

2. All pneumothoraces were abandoned immediately after adhesions were found to be not divisible.

Causes of Empyema in these Cases -

1. Induction of pneumothorax in the presence of acutely active and/or far advanced disease, 2 cases.

2. Maintenance of ineffective and useless collapse in all cases.

One case of unilateral pneumothorax was abandoned before thoracoscopy could be performed.

This patient had a pneumothorax induced while suffering from acute tuberculous pneumonia. The collapse was quite ineffective. Pus was aspirated on the occasion of the first aspiration 11 weeks after induction of the pneumothorax.

Cause of empyema was induction of pneumothorax during acute tuberculous pneumonia with rapid pleural involvement.

PART 3

TREATMENT AND RESULTS

I shall now present the results of the different types of treatment used in the eighty-one empyemata. For the purposes of tabulation the cases of "pure" not pyogenically infected empyemata will be termed Group A, and those secondarily infected will be termed Group B. Thirty-four (43.6%) of the 78 patients had empyemata which became infected with pyogenic organisms, but as one patient with bilateral empyema had both sides secondarily infected, thirty-five (43.2%) of the 81 empyemata fall into Group B.

To obviate confusion in the presentation of the results, it was considered wiser to deal first with the fifty cases of unilateral pneumothorax and empyema; secondly, with the twenty-five cases of bilateral pneumothorax and unilateral empyema; and thirdly, the three cases of bilateral empyema. While this necessitates some degree of repetition in the Tables, it avoids complications in dealing with the three bilateral empyemata, where one patient had different treatment used on each side, an d the other two patients each had one empyema falling into Group A, and one falling into Group B.

Before proceeding to present details of the type of treatment used and the survival of the patients concerned in each Group, a summary of cases of treatment and of survival is given in the Tables 48, 49, 50 and 51.

Seven different types of treatment were employed. These are given as contractions in the Tables and their complete description is given here. A, D, and L.S.O. in the Tables mean Alive, Dead, and Lost Sight Of, respectively.

The treatments used were as follows :-

1. Simple aspiration and air replacement.
2. Lavage with Azo T. solution after aspiration.
3. Aspiration followed by lavage with Azo T and combinations of Azo T., normal saline, eusol, methylene blue, Carrel-Dakin solution, etc.
4. Aspiration only or combined with Azo T. and saline lavage, plus sulphonamide powder or penicillin intra-pleurally.
5. Aspiration, lavage with Azo T., saline, etc. and finally closed drainage by self-retaining catheter.
6. Oleothorax.
7. Thoracoplasty.

TABLE 48

Treatment & Results of Treatment.

78 Patients

Type of Treatment	GROUP A CASES				GROUP B CASES				A AND B COMBINED			
	Total No. of Cases	Alive	Dead	L.S.O.	Total No. of Cases	Alive	Dead	L.S.O.	Total No. of Cases	Alive	Dead	L.S.O.
Aspiration and air replacement	17	7	9	1	6 x	0	4	2	23	7	13	3
Aspiration and lavage with Azo T. sol.	9	5	4	0	2	0	1	1	11	5	5	1
Aspiration and lavage with combination of solutions	8	2	5	1	4	1	3	0	12	3	8	1
Aspiration, lavage and sulphonamide powder or penicillin intrapleurally	0				6	1	5	0	6	1	5	0
Aspiration, lavage and final tube drainage	0				8	1	7	0	8	1	7	0
Oleothorax	5	3	2	0	4 X	2	2	0	9	5	4	0
Thoracoplasty	5	5	0	0	4	2	1	1	9	7	1	1
Total	44	22 (50%)	20 (45%)	2 (4.5%)	34	7 (20.6%)	23 (67.6%)	4 (11.8%)	78	29 (37.2%)	43 (55.1%)	6 (7.7%)

x The six cases in Group B treated by aspiration include one patient with bilateral empyema treated on both sides by aspiration.

X Include two cases of bilateral empyema, one treated on both sides by oleothorax; the other was treated by oleothorax on the left side and on the right side by aspiration and pleural lavage with Azo T solution.

Table 48 shows that of the seventy-eight patients who developed empyema, either "pure" or "mixed" type, forty-three are dead (55.1%) and twenty-nine (37.2%) are alive. Six patients (7.7%) were lost sight of. The period of survival was at the longest 11½ years, and at the shortest 3½ years.

The figures in Table 48 include all cases of empyema, whether in unilateral or bilateral pneumothorax. With any type of treatment one could assume that the cases of bilateral pneumothorax with unilateral empyema will fare worse than cases of unilateral pneumothorax and empyema, while cases of bilateral empyema will fare worst of all.

Tables 49, 50 and 51 show treatment and survival of the fifty cases of empyema in unilateral pneumothorax and in the twenty-five cases of unilateral empyema in bilateral pneumothorax. Group A and Group B cases are shown separately. Table 49 shows the results when Groups A and B are combined.

TABLE 49

Summary of Results of Treatment: 50 Unilateral Empyemata

Treatment	GROUP A				GROUP B				GROUPS A & B COMBINED			
	Total No. of Cases	A	D	LSO	Total No. of Cases	A	D	LSO	Total No. of Cases	A	D	LSO
Aspiration	8	4	3	1	4	0	2	2	12	4	5	3
Aspiration & lavage with Azo T.	7	4	3	0	1	0	1	0	8	4	4	0
Aspiration and lavage with comb.solutions	5	2	3	0	3	1	2	0	8	3	5	0
Aspiration and lavage plus sulphonamide powder or penicillin intrapleurally	0	-	-	-	4	1	3	0	4	1	3	0
Aspiration, lavage and final tube closed drain.	0	-	-	-	5	0	5	0	5	0	5	0
Oleothorax	3	2	1	0	1	0	1	0	4	2	2	0
Thoracoplasty	5	5	0	0	4	2	1	1	9	7	1	1
Total	28	17	10	1	22	4	15	3	50	21	25	4

Of the total of fifty patients, twenty-one (42%) are alive; twenty-five (50%) are dead, and four (8%) are lost sight of.

Of the twenty-one alive, seventeen (80.9%) were in Group A and four (19.1%) in Group B.

Of the twenty-five dead, a total of fifteen (60%) were in Group B and ten (40%) in Group A. One of the Group B cases lost sight of was known to have survived at least three years.

Details of the treatment of these Groups are given later.

TABLE 50

Summary of Results - 25 Bilateral Pneumothoraces with Unilateral Empyema

Treatment	GROUP A				GROUP B				GROUPS A & B COMBINED			
	Total No. of Cases	A	D	LSO	Total No. of Cases	A	D	LSO	Total No. of Cases	A	D	LSO
Aspiration	9	3	6	0	1	0	1	0	10	3	7	0
Aspiration and Azo T.	2	1	1	0	1	0	0	1	3	1	1	1
Aspiration & comb. solutions	3	0	2	1	1	0	1	0	4	0	3	1
Aspiration, lavage and sulphonamide powder and penicillin	0	0	0	0	2	0	2	0	2	0	2	0
Aspiration, lavage, final cl. drainage	0	0	0	0	3	1	2	0	3	1	2	0
Oleothorax	2	1	1	0	1	1	0	0	3	2	1	0
Thoracoplasty	0	0	0	0	0	0	0	0	0	0	0	0
Total	16	5	10	1	9	2	6	1	25	7	16	2

Of the total number of twenty-five cases, sixteen (64%) were in Group A and nine (36%) were in Group B. Sixteen (65%) of the twenty-five cases are dead; seven (28%) of the twenty-five are alive. Ten of the sixteen in Group A, equal to 62.5% are dead, and five, equal to 31%, are alive. Six of the nine cases in Group B, equal to 66.6% are dead, and two, equal to 22.2%, are alive.

The "lost sight of" case in Group B was known to have survived 5½ years.

Three cases of Bilateral Empyema.

Case 1 had both empyema secondarily infected. He was treated by aspiration only on both sides. He is dead.

Case 2 had one empyema secondarily infected and the other not. He was treated by oleothorax on both sides. He is alive.

Case 3 had secondary infection on one side and one remained free from secondary infection. She was treated on the side not secondarily infected, by aspiration only, and on the secondarily infected side she had an oleothorax. She is also dead.

Further details of these cases will be given later.

TABLE 51

Group A and B cases Combined: Treatment and Survival of Seventy-Five Cases.

Type of Treatment	50 Unilateral Pneumothoraces and Empyema				25 Bilateral Pneumothoraces and Unilateral Empyema			
	Total No.of Cases	Alive	Dead	L.S.O.	Total No.of Cases	Alive	Dead	L.S.O.
Aspiration and air replacement	12	4	5	3	10	3	7	0
Aspiration and Azo T lavage	8	4	4	0	3	1	1	1
Aspiration and lavage with comb. solutions	8	3	5	0	4	0	3	1
Aspiration and lavage and penicillin and sulphonamide powder intra pleurally	4	1	3	0	2	0	2	0
Aspiration and final tube drainage	5	0	5	0	3	1	2	0
Oleothorax	4	2	2	0	3	2	1	0
Thoracoplasty	9	7	1	1	0	0	0	0
Total	50	21 (42%)	25 (50%)	4 (8%)	25	7 (22%)	16 (64%)	2 (8%)

DETAILS OF TREATMENT

The following Tables give details of the different types and duration of treatment employed in fifty cases of empyema in unilateral pneumothoraces and in twenty five cases of unilateral empyema in bilateral pneumothoraces. The three cases of bilateral empyema will be considered separately.

Survivals and deaths of patients are presented graphically on pages 115 and 116 and following page 117.

Seventy Five Empyemata

Treatment

1. The simplest method of treatment is by aspiration followed by air replacement.

TABLE 52

Twenty-two cases were treated by this method.

Unilateral A.P. and empyema.

Group A - 8 Cases

Case No.	Duration of Treatment	Fate of Patient	Survival after Start of Empyema.
	Months		
1	6	Alive ; working	7 years 6 months
2	2	" "	5 years
3	4	" "	8 years 6 months
4	11	" "	4 years
5	1	Dead	not known
6	3	Dead	$5\frac{1}{2}$ months
7	1	Lost sight of	not known
8	1	Dead	7 years

Thus in this group of eight cases, four are alive, well and working; three are dead, and one is lost sight of. This last case was known to be alive three years after empyema began.

Aspiration only.

TABLE 53

Group B - Four cases Unilateral A.P. and Empyema.

Case No. q	Duration of Treatment. Months	Fate of Patient	Survival after start of empyema
1	24	Dead	10 years 3 months.
2	2	Lost sight of	Known to have survived 3 years then lost sight of.
3	1	Dead	1 month after spont. pneumothorax.
4	1	Lost sight of	Not known.

Of four cases in this secondarily infected group, two are known to be dead and two are lost sight of - fate unknown.

TABLE 54

Group A - 9 cases Bilateral Pneumothorax: Unilateral Empyema

Case No.	Duration of Treatment. Months.	Fate of Patient.	Survival after start of empyema
1	4	Dead	4 years
2	3	Alive; not well	4 years 8 months
3	4	Dead	1 year 7 months

TABLE 54 (Continued)

Case No.	Duration of Treatment. Months	Fate of Patient.	Survival after start of empyema
4	5	Dead: contra lateral spon. pneum.	3 years 1 month
5	2	Alive: working	4 years 6 months
6	1	Dead: contra lateral spont. pneum.	1 year
7	1	Dead	4 years 6 months
8	6	Dead	10 years 6 months
9	23	Alive; working	7 years 6 months.

In the case of the two men alive, well and working, one (No. 5) had his pneumothorax continued on the empyema side for $2\frac{1}{2}$ years; the other (No. 9) had his pneumothorax continued after empyema for 4 years and 2 months.

TABLE 55

Group B - 1 case Bilateral Pneumothorax: Unilateral Empyema

Case No.	Duration of Treatment. Months.	Fate of Patient.	Survival after start of empyema
1	2	Dead	$7\frac{1}{2}$ months.

This patient got a spontaneous pneumothorax 4 weeks after adhesion section; the pneumothorax was then abandoned.

2. Treatment by Aspiration and lavage with AzoT. Solution.

Eleven cases were treated solely by this method.

TABLE 56

Group A - 7 Cases-Unilateral Pneumothoraces

Case No.	Duration of Treatment Months	Fate of Patient	Survival from onset of empyema
1	3	Alive ;working	4 years 8 months
2	5	Dead	2 years 6 months
3	11	Dead	2 years 2 months
4	3	Alive; working	8 years 3 months
5	20	Alive ;working	4 years
6	5	Dead	3 years
7	8	Alive ;working	5 years 2 months

Of seven cases in this group, four are alive,well and working after a considerable period from onset of empyema; three are dead.

Group B - One case

Case No.	Duration of Treatment Months	Fate of Patient	Survival from onset of empyema
1	24 (12 as out patient)	Dead	3 years

TABLE 57

Group A - 2 cases Bilateral Pneumothorax: Unilateral empyema

Case No.	Duration of Treatment. Months.	Fate of Patient.	Survival after start of empyema
1	7	Alive; working	6 years
2	18	Dead	2 years 4 months

Case No. 1 got a spontaneous pneumothorax through a pleura studded with tubercles one week after adhesion section. The pneumothorax was abandoned 10 months after the broncho-pleural fistula occurred. Thus she has lived so far 5 years and one month after the pneumothorax was abandoned.

Group B - 1 case.

Case No.	Duration of Treatment. Months.	Fate of Patient.	Survival after start of empyema.
1	6	Lost sight of.	Known to have survived 5 years 10 months

This patient got a spontaneous pneumothorax through a ruptured tension cavity 10 weeks after adhesion section. Her pneumothorax was abandoned 15 months after empyema appeared.

3(a) Treatment by Aspiration and Lavage with combinations of Azo T, normal saline, Eusol, Carrel-Dakin Solution, etc.

Eight cases were treated by the above methods.

TABLE 58

Group A - 5 Cases-Unilateral Pneumothoraces.

Case No.	Duration of Treatment. Months.	Fate of Patient.	Survival after start of empyema
1	11	Dead (spont. pneum.)	2 years 4 months
2	5	Dead	5 years 6 months
3	7	Alive (T.B. Hip now)	10 years
4	1	Dead	4 years
5	5	Alive and working	10 years

In this group of 5 patients, three are dead and two alive, one of whom is well and working. The other has a tuberculous hip joint.

Group B - 3 cases.

Case No.	Duration of Treatment. Months.	Fate of Patient.	Survival after start of empyema
1	1½	Dead (meningitis)	2 months
2	6	Dead	7½ months
3	5	Alive	11 years

In this group of three patients, two are dead and one alive. Case No. 2 got a haemothorax after an open pneumolysis which followed two unsuccessful attempts

at closed pneumolysis.

Case No. 3 is alive but is very ill, and requires hospital treatment.

3(b) Treatment by Azo T and normal saline lavage with aspiration.

Four cases were treated by this method.

TABLE 59

Group A - 3 Cases Bilateral Pneumothorax: Unilateral Empyema

Case No.	Duration of Treatment Months	Fate of Patient.	Survival after start of empyema
1	2	Dead	7 years
2	2	Dead	5 years 8 months
3	6	Lost sight of	Not known

Case No. 2 got a spontaneous pneumothorax 12 hours after adhesion section. Her empyema appeared then and the pneumothorax was abandoned.

Group B - 1 case

Case No.	Duration of Treatment. Months	Fate of Patient.	Survival after start of empyema
1	11	Dead	9 years

This patient got a spontaneous pneumothorax 11 months after adhesion section through a ruptured basal cavity. His A.P. was maintained for 6 years after

this. He died 3 years later.

---

4. Aspiration and Azo T. or saline lavage, plus in all cases, instillation intra-pleurally of penicillin or sulphonamide powder.

TABLE 60

Group A - No cases. Group B - 6 cases

Group B - 4 cases -Unilateral A.P. and Empyema.

Case No.	Type of Treatment	Duration Months	Fate of Patient	Survival from onset of empyema
1	Azo T. lavage sulphonamide powder, 20g.m. in saline	7	Dead	2 years 9 months
2	Azo T. & saline lav. 70,000 units penicillin	2	Dead	7 months
3	Azo T. & saline lav.; 21 gms. sulph. powder	3	Dead (spont. pneum.)	5 months
4	Aspiration only; 170,000 units penicillin	4	Alive	3½ years

Of the four patients in this group, all secondarily infected cases, three are dead; the patient still alive has survived 3½ years. The sulphonamide powder

intra-pleurally was used against staphylococci, streptococci and pneumococci in one case, and staphylococci in the other case, but was found to have no effect on these organisms.

TABLE 61

Group B - 2 cases Bilateral A.P. Unilateral Empyema.

Case No.	Duration of Treatment. Months.	Fate of Patient.	Survival after start of empyema
1	8 300,000 units penicillin	Dead	4 years
2	1 99 units penicillin	Dead	7 months

Case No. 2 got a contra-lateral spontaneous pneumothorax and died 4 weeks later.

5. Aspiration, lavage with Azo T, saline, etc. and finally closed drainage by self-retaining catheter.

TABLE 62

8 Cases - All Group B - Unilateral A.P. and Empyemata.

Case No.	Type of Treatment.	Duration of Drainage Treatment Months	Fate of Patient	Survival after start of empyema
1	Azo T, saline flavine, 15 cc. cod liver oil	6	Dead	1 yr 6 mths.
2	Flavine 1:2000	4	Dead	9 months
3	Azo T, 31 gm. sulphonamide powder in cod liver oil	6	Dead	8 months
4	Azo T lavage	3	Dead	11 months
5	Azo T lavage	not known; done as out-patient after leaving Sanatorium	Dead	5 yrs.6 mths

All the patients in this group are dead. The first four had broncho-pleural fistulae as the cause of their empyema.

TABLE 63

3 Cases - Group B - Bilateral A.P.; Unilateral Empyema.

Case No.	Type of Treatment	Duration Months Asptn.	Tube.	Fate of Patient	Survival from Start of Empyema
1	Azo T. lavage	6	13	Alive	7 yrs. 6 mths
2	Azo T. and Saline lav.	2	6	Dead	1 year
3	Lavage with sotn. of Methylene blue: 25c.c. left in chest	1	6	Dead	11 months

---

6. Oleothorax

Twelve patients in all were treated by oleothorax. Three of these patients ultimately came to thoracoplasty and are considered in the group treated by thoracoplasty. Of the nine patients in whom oleothorax was the final form of treatment ,five came into Group A and four into Group B. Four patients had empyema in unilateral pneumothorax and three had unilateral empyema in bilateral pneumothorax.

Two patients with bilateral empyema of which three empyemata were treated by oleothorax will be considered separately under "Bilateral Empyema", (page 112).

TABLE 64

Group A - 3 cases Unilateral A.P. and Empyema.

Case No.	Preliminary Treatment	Duration Months	Oleothorax	Duration Months	Fate of Patient	Survival after start of empyema
1	Azo T lav.	6	290 cc cod liver oil	2	Alive	7 yrs.
2	Aspiration only	1	35 cc. Gomenol	1	Dead	8 yrs 2 mths.
3	Azo T. lav	6	35 cc. cod liver oil then Azo T	1	Alive	8 yrs.

Group B - 1 case.

Case No.	Preliminary Treatment.	Duration Months	Oleothorax	Duration Months	Fate of Patient	Survival after start of empyema
1	Azo T lav proflavine 1/1000, 375,000 units penicillin	2	225 cc cod liver oil	2	Dead	1 yr 4 mths

Of four unilateral empyemata treated by oleothorax, two are alive and two dead.

The case in Group B got a spontaneous pneumothorax and broncho-pleural fistula one week after cauterization of adhesions.

TABLE 65

Bilateral Pneumothorax: Unilateral Empyema.

Two cases, Nos. 1 and 2 are in Group A, and one, case No. 3, was in Group B.

Case No.	Preliminary Treatment	Duration Months	Oleothorax	Duration Months	Fate of Patient	Survival from start of empyema
Group A						
1	Azo T lavage	2	695 cc cod liver oil	7	Alive	8 yrs.
2	Azo T lavage	5	95 cc cod liver oil	5	Dead	4 yrs.
Group B						
3	Azo T lavage 350,000 units penicillin	5	1,380 cc cod liver oil	21	Alive	6½ yrs.

Case No. 1 got a spontaneous pneumothorax 4 months after the oleothorax had been induced.

Case No. 2 got a contra-lateral spontaneous pneumothorax, the opening in the pleura being observed at thoracoscopy.

7. Thoracoplasty

Thoracoplasty was performed in nine of the unilateral empyema cases. Five cases were in Group A and four in Group B. Details of these cases, with the treatment used before thoracoplasty, are given in Table 66.

TABLE 66

7 Thoracoplasty

Case No.	Preliminary treatment before Thoracoplasty	Duration of this treatment	No. of Ribs	Survival from onset of empyema
Group A				
1	Aspiration only	6 months	8	Alive 4 years
2	" "	6 weeks	7	" 4½ years
3	" "	5 months	9	" 8 years
4	Azo T lavage oleothorax 100 cc cod liver oil	9 months	10	" 5 years
5	Azo T lavage	11 months	8	" 3 years 9 months
Group B				
6	Oleothorax 37 cc Gomenol Closed Drain and Acriflavine lav.	1 month 20 months	10	Lost sight of
7	Aspiration and lav. with half-saturated sol. urea. Azo T lavage Oleothorax of 40 cc cod liver oil and 192,000 units penicillin	4 months. 1 month 3 months	7	Alive 4½ years
8	Azo T and proflavine lavage	5 months	10	Alive 4 years
9	Aspiration and closed drainage	8 months	4 Basal Thoraco.	Dead 1 year 7 months

Case 5 was done in the presence of fairly severe contra-lateral disease.

It can be seen that of the nine cases submitted to thoracoplasty, seven are known to be alive, with survival periods varying from 8 years to three years and nine months. Three of the four secondarily infected cases are alive.

Bilateral Empyema

Three patients suffered from bilateral empyema. The treatment in these cases was as follows. The left pneumothorax was induced first in each case.

TABLE 67

Case 1 - Group B (both empyemata).

Case No.	Type of Treatment	Duration of Treatment Months	Fate of Patient	Survival from start of empyema
1	L.side: aspiration only	7		1 year 2 months after L.empyema
	R.side: aspiration only. A.P. abandoned before adhesion section.	1	Dead	11½ months after R. empyema

This patient got a spontaneous pneumothorax

on the left side four and a half months after adhesion section.

Case 2. This case had a secondary infection on the left empyema only.

Case No.	Type of Treatment.	Duration of Treatment Months.	Fate of Patient	Survival from start of empyema
2	L.side: Azo T lavage and cod liver oil oleothorax 290 c.c. R.side: Azo T lavage	8 months 4½ " 6 months	Dead	4 years after start of L. 3 years after R.

Case 3. This case had a secondary infection of the right empyema only. Both empyemata were treated by oleothorax.

Case No.	Type of Treatment.	Duration of Treatment Months.	Fate of Patient.	Survival from start of empyema
3	L.side: Azo T lavage, 65 cc. cod liver oil R.side: Azo T and Eusol lavage. Cod liver oil 2,300 cc. Tube drainage	17 8 5 2	Alive	6 years - still having occ. aspiration on R. side.

This patient is fairly well and is doing part-time work.

Survivals in seventy-eight Patients.

Of the total number of seventy-eight patients, twenty-nine (37.2%) are known to be alive and have survived periods ranging from 11 to 3½ years following onset of empyema. Length of survival from onset of empyema is known definitely in twenty-eight of these patients.

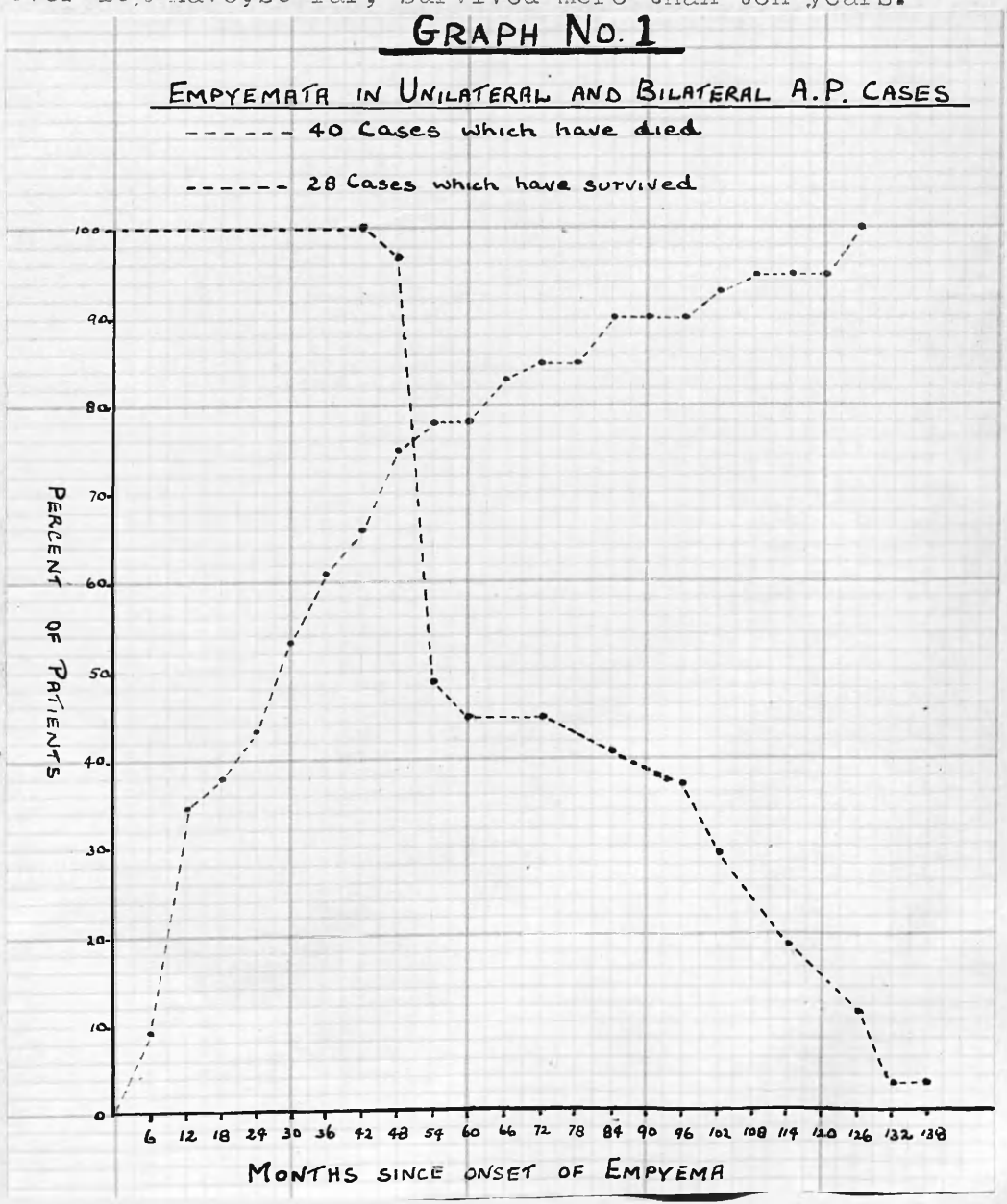
Forty-three patients (55.1%) are known to be dead. Length of survival from onset of empyema is known in forty of these patients.

Six patients were lost sight of through records having been lost or destroyed, but two were known to have survived periods of 5½ and 3 years respectively.

The graphs shown on the following pages show the survival and death rates for both unilateral and bilateral pneumothorax cases combined and for unilateral and bilateral pneumothorax cases separately.

Deaths - Graph No. 1 below shows that within six months of onset of empyema about 10% of the forty patients had died; within three years 60% had died ; by seven years 90% were dead.

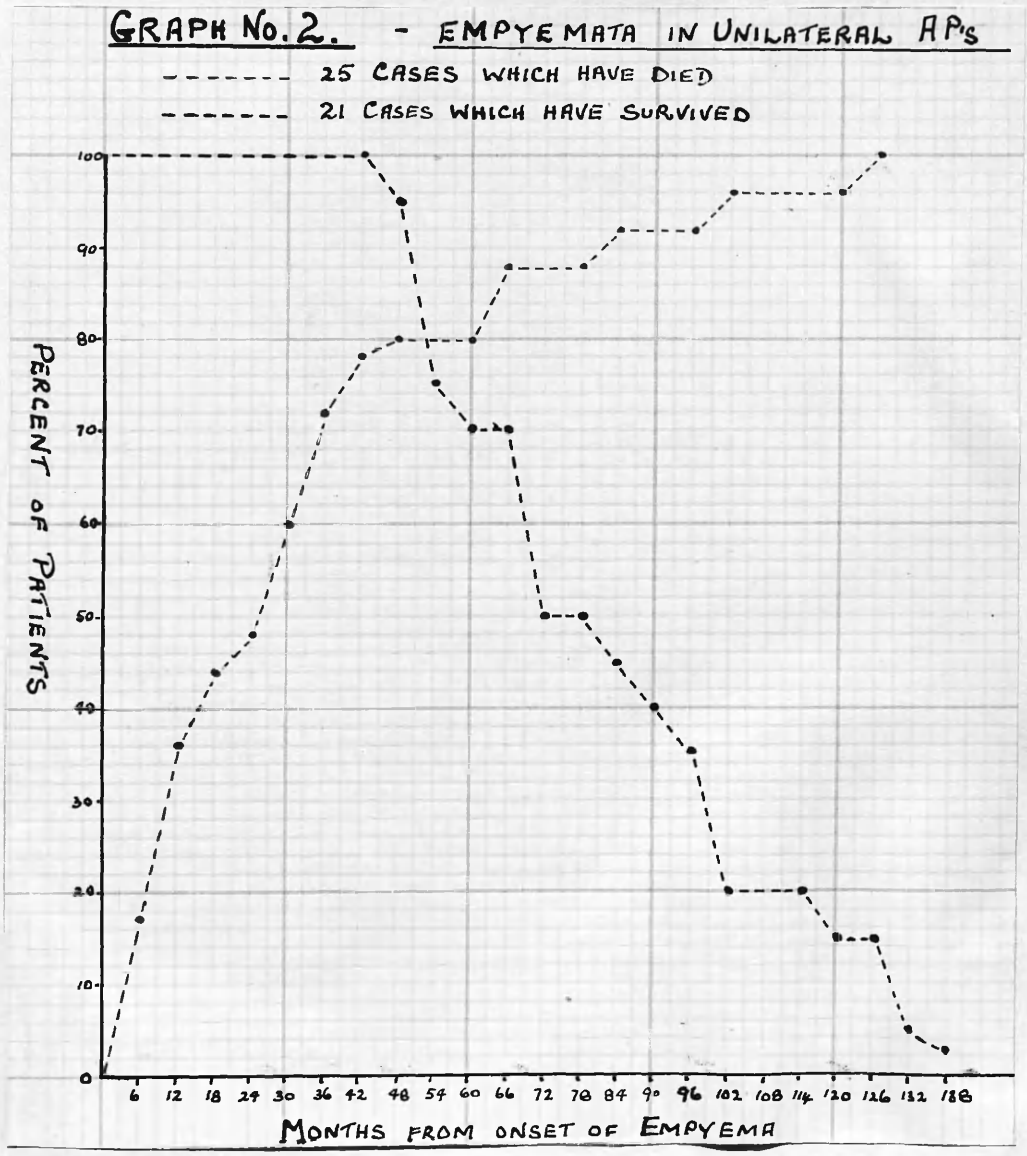
Survivals - Regarding the twenty-eight cases in which survival is known, it is seen that 100% survived three and a half years, 50% four and a half years, and a little over 10% have, so far, survived more than ten years.



Graph No. 2 shows survivals and deaths in forty-six of the fifty empyema cases which occurred in patients with unilateral pneumothoraces.

Of the twenty-five deaths, 48% had occurred within two years of onset of empyema, 80% within 5 years and 90% in a little over $6\frac{1}{2}$ years.

Of the twenty-one cases of survival, 100% have lived $3\frac{1}{2}$ years, 50% have survived $6\frac{1}{2}$ years and 15% have survived 10years.



Graph No. 3 shows the duration of survival of sixteen patients who have died and of seven patients who are alive after unilateral empyema in bilateral pneumothorax.

The only surviving case of bilateral empyema is not included.

It can be seen that whereas in the cases of unilateral pneumothorax and empyema, 72 % of the deaths had occurred within three years, a little under 50 % of the cases in which control of the contralateral side had been obtained by pneumothorax , had died after an interval of three years from onset of empyema.

The graph of survivals shows that 100 % of the bilateral pneumothorax cases survived four years, and 85 % survived four and a half years.

The unilateral pneumothorax cases, on the other hand , shows survival for four and a half years of 78 % .

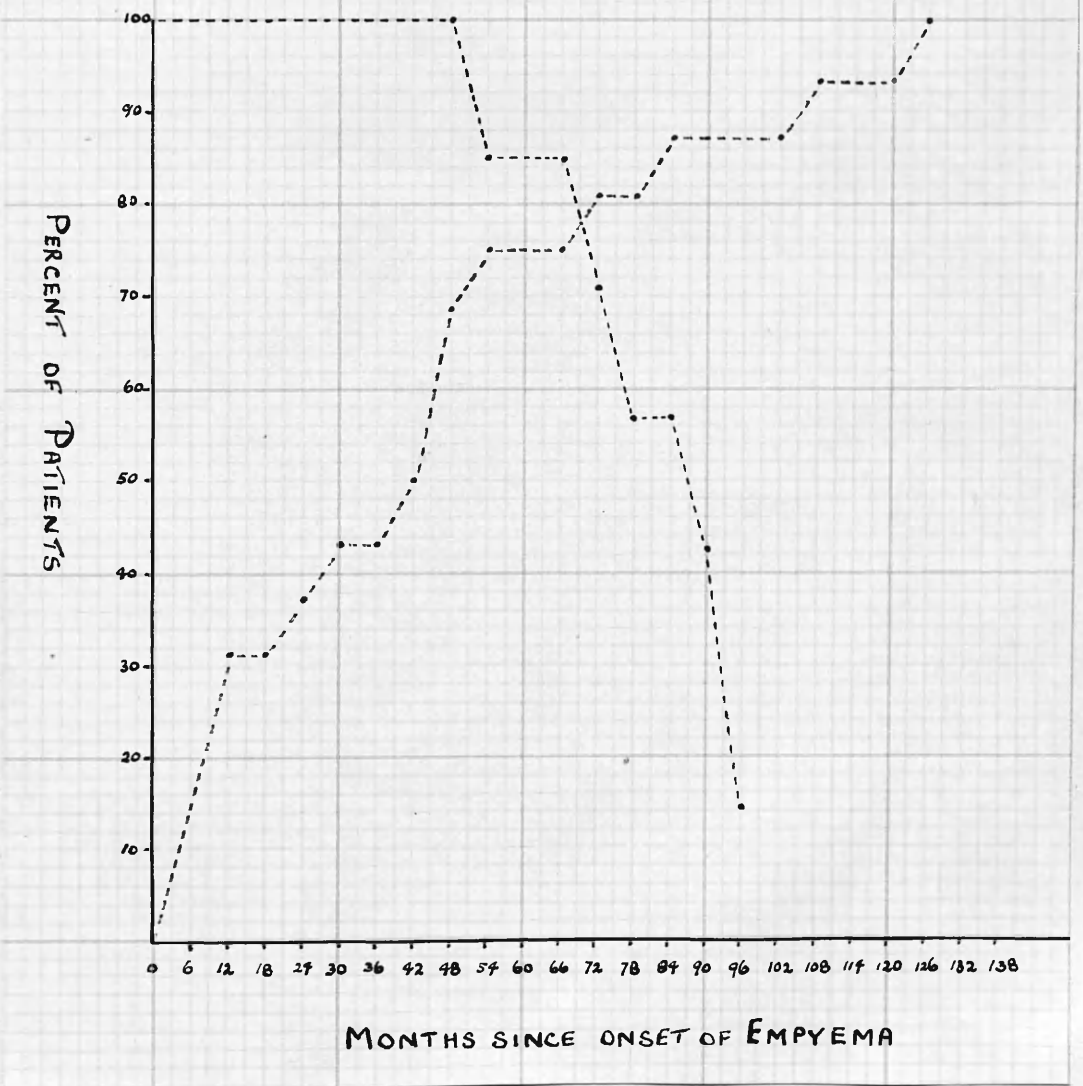
So far, 50 % of the bilateral A.P. cases have survived more than seven years, and 50 % of the unilateral A.P. cases have survived six and a half to seven years.

GRAPH NO 3.

UNILATERAL EMPYEMATA IN BILATERAL A.Ps

16 Cases which have died

7 Cases which have survived



Pleuro-Cutaneous Sinuses

Treatment of the eighty-one empyemata resulted in twenty -two cases (27.1%) developing pleuro-cutaneous sinuses. One other patient developed tuberculous nodules in the skin following aspiration and Azo T. lavage.

Sinuses resulted in the different forms of treatment as shown in Table 68.

TABLE 68

Pleuro-Cutaneous Sinuses. 22 Cases

Treatment.	Total Treated	Cases of Sinus		Alive	Dead	Lost Sight of.
		No.	%			
Aspiration only	23	3	13.0	0	3	0
Aspitn. and Lavage with Azo T. and combined soltns	23	3	13.0	2	1	0
Asptn, lavage and Sulphon-amide powder and penicillin intra-pleurally	6	2	33.3	0	2	0
Aspirtn. etc., then closed drainage	8	8	100.0	2	6	0
Oleothorax	9	6	66.6	4	2	0
Total	69	22		8	14	0

Only 69 patients are shown in the Table. The remaining nine cases were treated by thoracoplasty. Fourteen (63.7%) of the twenty-two patients are dead and eight (36.3%) are alive. The longest possible survival was 10 years and 9 months and the shortest 3 years from first appearance of sinuses.

Apparently (as would be expected) the treatment most likely to lead to sinus formation is tube drainage.

Oleothorax is the second worst type of treatment while the treatment leading to the fewest cases of sinuses was aspiration either alone or with lavage.

Of the six oleothorax cases, five had oleothorax as their final treatment. One case is still having aspirations, while the sixth case was finally treated by thoracoplasty.

Of the two cases alive which had Azo T. lavage and aspiration, one is very ill; the other ultimately had a thoracoplasty, and is well and working. A similar position obtains as regards two patients alive after tube drainage treatment.

Thirteen (59%) of the twenty-two cases with sinuses had had broncho-pleural fistulae.

Duration of Treatment before Sinuses developed.

Six cases (27.3%) developed sinuses between three and six months and eight cases (36.4% between six and nine months from the start of treatment of their empyemata. In the other eight cases the date of development of sinuses is not known. One case had to have aspirations stopped after 4½ months because of the development of multiple sinuses. Two cases were turned down for thoracoplasty because of the state of their chest walls.

Treatment of Sinuses

Various combinations of cod liver oil and sulphonamide powder in paste, promin jelly, cod liver oil alone and penicillin powder alone were used in attempts to close sinuses. None were successful. The only satisfactory treatment was excision at thoracoplasty. One patient only had tubercle bacilli isolated from the sinus. Treatment was by cod liver oil dressings and was unsuccessful. The sinus was excised at thoracoplasty.

State of Sputum in Patients discharged from Sanatorium.

Of the total number of seventy-eight empyema cases, forty-three (55.1%) are dead and twenty-nine (37.2%) are alive. Six patients (7.7%) were lost sight of. Of the forty-three patients who died, sixteen (37.2%) died in hospital. Twenty-seven (62.8%) died at varying intervals after discharge.

The state of sputum conversion at discharge of the twenty-seven patients who have died since discharge and of the twenty-nine still alive is shown in Table 69.

TABLE 69. 56 cases discharged from Hospital.

State of sputum at Discharge	Alive				Dead				Alive & Dead	
	Unilateral Pneumo-thorax No.	Bilateral Pneumo-thorax No.	To-tal	% of to-tal	Unilateral Pneumo-thorax No.	Bilateral Pneumo-thorax No.	To-tal	% of to-tal	Total Combined No.	%
Positive	2	2	4	23.5	8	5	13	76.5	17	30.4
Negative	14	4	18	66.7	5	4	9	33.3	27	48.2
No sputum	5	2	7	58.3	2	3	5	41.7	12	21.4
Total	21	8	29		15	12	27		56	100.0

Survival of both groups of patients will be shown in the following pages.

Sputum on Discharge.

TABLE 70. 27 Patients who have died since discharge.

Sputum at Discharge	Unilateral A.P. Cases	Bilateral A.P. Cases	Total	%
Positive Sputum	8	5	13	48.2
Negative Sputum	5	4	9	33.3
No Sputum	2	3	5	18.5
Total	15	12	27	100.0

Of the thirteen patients discharged with a positive sputum the survival was as follows: Erythocyte sedimentation rate on discharge is also given.

See Table 71 on page 124.

Patients discharged with Positive Sputum who have since died.

TABLE 71. 13 Patients.

Case No.	Unilateral Pneumothoraces. Survival after discharge. Years	E.S.R. at discharge. m.m. 2 hrs. (W.)	Case No.	Bilateral Pneumothoraces. Survival after discharge. Years.	E.S.R. at discharge m.m. 2 hrs. (W.)
1	1 4/12	123	1	3 1/12	62
2	1 7/12	71	2	4	48
3	2 2/12	52	3	4	42
4	2 6/12	23	4	4	34
5	3	39	5	4 6/12	51
6	4	16			
7	5½	12			
8	Not known	14			

The above Table seems to show that in general terms patients with a positive sputum on discharge survived a longer or shorter time, according to the rapidity of the sedimentation rate at discharge.

Patients discharged with Negative Sputum who have died.

TABLE 72. 9 Patients

Case No.	Unilateral A.P. Survival after discharge. Years	E.S.R. at Discharge m.m. 2 hrs. (W.)	Case No.	Bilateral A.P. Survival after discharge. Years	E.S.R. at Discharge m.m. 2 hrs. (W.)
1	2 7/12	41	1	1 7/12	71
2	3	30	2	4 6/12	27
3	3 6/12	23	3	6	28
4	5 6/12	66	4	7 6/12	20
5	10	46			

It would appear that while survival after discharge with negative sputum appears to be related to the rapidity of the sedimentation rate at the time of discharge, there is not the same correlation between rapid sedimentation rate and shorter survival as is found with cases which had positive sputum on discharge. This is as would be expected, namely, that the important factor in length of survival is the state of the sputum, not the rapidity of the sedimentation rate.

Patients discharged with No Sputum who have died.

TABLE 73. 5 Cases

Case No.	Unilateral A.P. Survival after discharge Years	E.S.R. at discharge m.m. 2 hrs. (W.)	Case No.	Bilateral A.P. Survival after discharge. Years	E.S.R. at discharge m.m. 2 hrs. (W.)
1	7	40	1	2 6/12	40
2	8 2/12	10	2 X	4	43
			3	7	30

X Case of bilateral empyema.

No conclusions can be drawn from the figures in Table 73.

Patients discharged from Sanatorium who are known to be alive.

Twenty-nine patients (37.2%) of the total number of seventy-eight cases of empyema are alive. Survival ranges from $3\frac{1}{2}$ to 10 years from date of discharge from hospital.

Of these twenty-nine patients, the state of sputum at discharge is shown in Table 74.

TABLE 74

29 Patients now Alive

Sputum at discharge	Unilateral Pneumothoraces	Bilateral Pneumothoraces	Total	%
Positive	2	2	4	13.8
Negative	14	4	18	62.1
No Sputum	5	2	7	24.1
Total	21	8	29	100.0

The following Tables show the survival so far of these patients. Sedimentation rate at discharge is also given.

TABLE 75

4 Patients now alive, discharged with Positive Sputum.

Case No.	Unilateral Pneumothoraces. Survival after discharge Years	E.S.R. at discharge m.m. 2 hrs (W.)	Case No.	Bilateral Pneumothoraces. Survival after discharge. Years	E.S.R. at discharge m.m. 2 hrs. (W)
1	4	65 m.m.	1 X	6	95
2	8	6 m.m.	2	$7\frac{1}{2}$	42

X This case was a bilateral empyema, who is still having aspirations on the right side. He was treated by oleothorax on both sides.

There are only four cases in this category. Thirteen others discharged with positive sputum have died.

TABLE 76

18 Patients now alive, discharged with Negative Sputum.

Case No.	Unilateral Pneumothoraces. Survival after discharge Years	E.S.R. at discharge m.m. 2 hrs. (W.)	Case No.	Bilateral Pneumothoraces. Survival after discharge. Years.	E.S.R. at discharge m.m. 2 hrs. (W.)
1	3½	23	1	4	50
2	3¾	17	2	4½	27
3	4	17	3	6	28
4	4	19	4	7½	20
5	4	31			
6	4½	18			
7	4½	35			
8	5	22			
9	5½	39			
10	7½	27			
11	8½	3			
12	8½	5			
13	9¼	31			
14	10½	41			

There is no apparent correlation between length of survival and sedimentation rate at discharge. The important matter is the fact that the sputum was negative at discharge.

TABLE 77

7 Patients now Alive, discharged with No Sputum.

Case No.	Unilateral Pneumothorax. Survival after discharge. Years	E.S.R. at discharge m.m. 2 hrs. (W.)	Case No.	Bilateral Pneumothorax Survival after discharge Years	E.S.R. at discharge m.m. 2 hrs. (W.)
1	5	27	1	5	50
2	5 2/12	10	2	6½	32
3	7	16			
4	8	40			
5	9½	34			

There is no correlation between length of survival and sedimentation rate at discharge, but all these patients are alive, well and working.

Maintenance of Collapse after Onset of Empyema

After onset of empyema collapse was maintained in twenty-five (32%) and abandoned in fifty-three (68%) of the total number of seventy-eight patients.

With a follow-up which, at the longest from onset of empyema was 11½ years, and at the shortest 3½ years, the position regarding those alive and dead is shown in Table 78 below.

TABLE 78

	Alive	Dead	Lost sight of	Total
Collapse maintained	12	11	2	25
Collapse abandoned	17	32	4	53
Total	29	43	6	78

Of the twenty-five patients in whom collapse was maintained, twelve (48%) are alive. In five of these the collapse was maintained by oleothorax. Eleven patients (44%) in whom collapse was maintained are dead, and two have been lost sight of.

Of the fifty-three patients in whom collapse

by pneumothorax was abandoned, seventeen (32%) are alive, thirty-two (60.4%) are dead, and four (7.6%) are lost sight of.

Of the seventeen patients now alive, ten (59%) had no further treatment (apart from aspiration, etc.) while seven (41%) had thoracoplasty.

Of the thirty-two dead, twenty-one had no further treatment other than aspiration, while one had thoracoplasty.

Of the four cases lost sight of, one had thoracoplasty, but the other three had no further collapse treatment.

After abandonment of pneumothorax, seventeen patients (apart from one patient in whom thoracoplasty was performed) had a lung which remained more or less unexpanded. Of these seventeen, thirteen (76.4%) are dead, two are alive (11.8), and two are lost sight of.

Regarding the cases in which collapse was maintained, it is reasonable to point out that the treatment of empyema in these cases must have been satisfactory.

PART 4

DISCUSSION

DEFINITION AND INCIDENCE OF TUBERCULOUS EMPYEMA

Definition -

De Cecio and Potter (1939) and Goorwitch (1943) have commented on the varying opinions expressed in the literature as to which type of effusion constitutes an empyema during the course of artificial pneumothorax treatment.

I have used the definition suggested by Dickey (1943) which defines tuberculous empyema as a turbid or purulent exudate in which tubercle bacilli have been demonstrated, either on direct smear or on culture, or by animal inoculation. Ornstein and Ulmar (1939) consider that all tuberculous effusions should be termed empyemata. Munro-Ashman and Tate (1943), require that the effusion should,at least, be turbid and that tubercle bacilli be demonstrable on direct smear examination. Cutler(1941) used a similar definition, but Jones and Alexander (1934), Woodruff (1938) and Andersen (1949), while insisting that the exudate be turbid or purulent,do not insist on the demonstration of the tubercle bacillus in the exudate. Woodruff (1938), is satisfied that an

an empyema is tuberculous if tuberculosis of the underlying lung is proved, whilst Jones and Alexander (1934) and Andersen (1949) accept as proof of the tuberculous origin of the exudate the finding of tuberculous granulation tissue in biopsy specimens of the pleura.

Incidence -

Applying the definition of Dickey (1943) to this series, the incidence of empyema over a period of eight years between 1937 and 1945 works out at eighty - one , equivalent to 5.6% of the total number of 1,448 pneumothoraces.

There were sixteen other cases of turbid or purulent exudate but in none of these were tubercle bacilli ever demonstrated . If these cases are included , the incidence of empyema in this series rises to 6.7% of the total pneumothoraces.

The incidence in this series compares favourably with figures quoted in the literature, although obviously the incidence of empyema in any series of pneumothoraces will vary according to the definition of empyema accepted by the observer.

Frostad in Norway, quoted by Andersen (1949) has estimated the incidence at 10% as an average figure.

Alexander (1937) quotes figures ranging from nil (Ulrici, 600 cases) to twenty-one per cent (Hayes 151 cases).

Shipman (1942) also claimed to have no cases of empyema during a period of four years, while Wollaston (1940) had an incidence of only 2%.

Unverricht, quoted by Ustvedt (1942) in a series of 2,893 pneumothoraces had the low incidence of 1.1%, while Morrison (1948) reported an incidence of 24% in fifty pneumothoraces.

Further examples of the variation of incidence of empyema in pneumothorax are shown in Table 79.

TABLE 79

Incidence of Empyema in Pneumothorax

Author	No. of Cases of Pneumothorax	Incidence of Empyema %
Leaver and Hardaway (1937)	760	5.8%
Nicklas, Franklin and Savod (1937)	375	14.4%
Skavlem et al (1940)	898	10.8%
Mattill & Jennings (1940)	Not given	14.3%
Cutler (1941)	476	12.4%

Generally it may be said, despite the figures quoted in Table 79, that as experience of pneumothorax increased, the incidence of empyema has tended to fall.

Lilienthal (1925) suggests that between 10% and 20% of all exudates in pneumothorax become purulent.

Paquette (1926) quotes figures of incidence of 41.8% in 1926, 26.1% for the period 1920 to 1930, and only 9.4% for the period 1930 to 1944.

Rogstad, quoted by Andersen (1949), had an incidence of 6.4% of empyema in 918 patients, while other figures already quoted above show an incidence from 1940 onwards of 2% and nil.

ETIOLOGY

Type and Activity of Disease at Induction of Pneumothorax.

Of the total number of seventy-eight patients in this series, sixty-three (almost 81%) were suffering from either acute exudative disease or extensive unilateral cavitation, or had a large apical cavity at the time of induction of their pneumothorax.

Four cases were suffering from acute tuberculous pneumonia when pneumothorax was induced.

Fifty-three cases (69.2%) came into Salkin and Cadden's (1941) classification of far advanced disease, and sixty-eight (87.2%) into the different categories suggested by Rafferty (1944) as unsuitable for treatment by pneumothorax.

Sixty-one patients (78%) had symptoms of twelve months or less duration (counted from the time of the first appearance of symptoms before a doctor was consulted) and five cases (6.4%) only had bed rest after admission to the Sanatorium and prior to induction of pneumothorax of more than 2 weeks duration.

Table 19 shows that sixty-nine (85.2%) of the eighty-one empyemata had the pneumothorax induced when the erythrocyte sedimentation rate was 40 m.m. or more in two hours (Westergren).

In thirty-one instances (38%) , the e.s.r was either 80 m.m. or more (Westergren) when pneumothorax was induced. It has been our experience in the Cheshire Joint Sanatorium in recent years, that pneumothoraces induced when the e.s.r. is 40 m.m. or over in 2 hours(W.) have shown a proportionately higher incidence of effusion than those induced when the sedimentation rate was below 40 m.m. in 2 hours (W.).

All the above findings confirm the experience of most other observers.

Packhard, Hayes and Blanchet (1940), state that the more active the pulmonary lesion at the time of induction of pneumothorax , the more frequent and more serious the pleurisy. Pinner (1944),reported that acute and caseous involvement is frequently considered an absolute contra-indication to pneumothorax on account of the real danger of empyema. Table 18 shows that 28 patients in this series equal to almost 36% of the total number had their pneumothoraces induced when suffering from acute caseous disease. Hayes(1927), Skavlem and others(1940), and Raffert(1944) all agree that collapse of a lung by

pneumothorax while the disease is acute runs the risk of producing complicating effusion and empyema. Wollaston and Landau (1946), on the other hand, discussing sedimentation rate at the time of induction of pneumothorax and accepting the sedimentation rate as one indicator of activity, consider that a rapid sedimentation rate is itself not a contra-indication to inducing pneumothorax. These writers are of the opinion that effective collapse ,and not the initial sedimentation rate, is the significant factor in avoiding complications.

Whilst accepting the latter statement that collapse is very important in so far as a satisfactory collapse is more likely to control the disease, and that there is a correspondingly smaller risk of complicating effusion and empyema, our experience has been,as shown in Tables 19 and 20 that a high sedimentation rate at induction coincides with complications. This is still our experience and we are now finding fewer cases developing complicating effusions and empyemata by using the e.s.r. to indicate when a case needs time,or other measures, such as phrenic crush and pneumoperitoneum, to allow it to "cool off" before pneumothorax is induced.

Type of Collapse

Table 29 shows that of seventy-four cases of pneumothorax submitted to adhesion section, twenty-six cases (35.1%) had satisfactory collapse, and forty-eight (64.9%) had either incomplete or ineffective collapse after operation. Seven cases not submitted to adhesion section all had ineffective collapse. Thus, of the total number of eighty-one empyemata, fifty-nine (67.9%) developed in pneumothoraces either incompletely or ineffectively collapsed.

Edwards & Lynn (1939), Browning, Dundon and Ray (1941), Cutler (1941), Dickey (1943), Shields (1944) and Wollaston and Landau (1946) all agree that effusion and empyema are more prone to occur in pneumothoraces mechanically ineffective and maintained as such for too long a period.

It would seem, also, that complete or satisfactory collapse is the less common occurrence. Edwards & Lynn (1939) found complete division of adhesions possible in eighty-six (34%) of two hundred and fifty-five cases submitted to operation. Partial collapse was obtained in one hundred and forty cases (55%) and twenty-nine cases (11%) were found to be inoperable.

Chandler (1937) obtained complete collapse in 50%, Anderson and Alexander (1937) in 37%, although Jacobeus (1923) in his early cases claimed to have obtained complete collapse in 75%.

It may be surprising to note that in this series twenty-six cases (35.1%) of pneumothorax developed empyema despite satisfactory collapse. Matson, Matson & Bisaillon (1924), however, found that twenty-nine (49.2%) of fifty-nine empyemata in their series developed in cases of satisfactory collapse.

Packhard, Hayes & Blanchet (1940) suggest that in such cases "seepage of tubercle bacilli may occur from a sub-pleural focus into the pleural cavity after the pleura has been rendered very allergic by the previous mild infections."

The same observers note that a serous effusion may become purulent during a cold or any septic infection.

In this series the causes of empyema in the twenty-six cases in whom satisfactory collapse was obtained were, so far as could be ascertained, as follows:-

1. In eighteen (69.2%) despite satisfactory collapse , disease was not controlled through failure to achieve cavity closure. In eight of these cases broncho-pleural fistula developed.

2. Three cases had haemothorax develop following adhesion section.

3. Three cases developed complete atelectasis after adhesion section. Since routine bronchoscopy has been practised in the Sanatorium it has been found that such cases have always present endo-bronchial disease of one or more major bronchi. There is no reason to doubt that similar findings would have been reported in the three cases mentioned above.

4. In one case in which cavity closure was obtained , broncho-pleural fistula developed through a markedly tuberculous pleura.

5. In one case the exact cause of empyema (which was late in developing) was not ascertained.

Atelectasis.

Complete atelectasis of the lung occurred in twelve cases, equal to 14.8% of the total number of eighty-one empyemata and 16.2% of the seventy-four cases operated upon for adhesions. By atelectasis is meant the finding on the skiagram of a ground glass appearance of a lobe or of a whole lung accompanied by clinical signs such as mallaise and pyrexia of varying degree.

Only complete atelectasis of the whole lung is being considered in the cases of empyema under review, for the reason that, in general, our experience has been that localised lobar or segmental atelectasis has more usually resulted in healing and fibrosis of the affected area, with no massive effusion or empyema as a result. Complete atelectasis of an entire lung, on the other hand, has been followed by massive effusion and empyema. This has been observed also by Cuthbert and Nagley (1948).

It would appear that empyema may follow atelectasis as the result of -

1. Extension of peripheral bronchial disease to caseation and erosion of the visceral pleura with formation of broncho-pleural fistula.

Five of the twelve cases of atelectasis in this series developed demonstrable broncho-pleural fistulae.

In the presence of major endo-bronchial tuberculosis , massive collapse of the lung may occur with consequent spread of parenchymatous disease to the pleura.

In recent years , since routine bronchoscopy has been practised in the Cheshire Joint Sanatorium, the above findings have been confirmed in every case. Rapid re-aeration of the lung has not prevented the occurrence of broncho-pleural fistulae, (even after an interval of three months) in such cases and even after apparently satisfactory resolution of the tuberculous bronchitis by the use of streptomycin. This would seem to confirm the observation of Maher-Loughnan (1950), suggesting that tuberculosis of the smaller bronchi and bronchioles exists in all cases of atelectasis, and is , perhaps, the cause of lobar atelectasis occurring suddenly in cases of satisfactory collapse.

Table 23 shows no consistency of findings in the cases in which complete atelectasis occurred. This is not surprising in that any, or indeed, every case of pulmonary tuberculosis must at some time have a degree of

tuberculous bronchitis. It does, however, raise the question of why complete atelectasis occurs in some cases of pneumothorax and not in others.

To answer this question involves one in the complete pathology and etiology of atelectasis, for which there is not space in this thesis. Suffice it to say that one or more or all the cases which developed complete atelectasis may have had present one or all of the conditions mentioned below, which may induce atelectasis :

1. Obstruction of a major bronchus. Coryllos (1933), Kent (1942) , Paulson and Shaw (1949).

2. Kinking and partial stenosis of a major bronchus with progression later to"check-valve" occlusion in the presence of endo-bronchial tuberculosis. Korol (1936) , Rafferty (1943), Sampson (1937), Brantigan et al. (1942) , Viswanathan (1949). Partial stenosis of a bronchus has been found in most cases of atelectasis submitted to bronchoscopy in our Sanatorium in recent years. Check-valve mechanism is instanced by the five cases shown in Table 25 as having suffered broncho-pleural fistula. Plugs of secretion have been mentioned as a cause of atelectasis by inducing a check-valve mechanism similar to that induced by endo-bronchial tuberculosis. It has been our experience that such plugs of secretion are not commonly the cause of complete atelectasis.

3. Peripheral lung inflammation (pneumonitis) and tuberculosis of the small peripheral bronchi. Eloesser (1934), Pinner (1944), Barnwell, Littig and Culp (1937). Peripheral lung inflammation must have existed in five of the twelve cases shown in Table 23 as having unhealthy pleura. Tuberculosis of the small peripheral bronchi may well have existed in those cases in whom cavity closure was not obtained and also in those cases in which bronchopleural fistulae occurred.

4. Active contraction of the alveoli caused by reflex increase of pulmonary tone, Xalabarder (1949).

Xalabarder (1949) has revived this theory of a reflex cause for pulmonary or segmental atelectasis and while it may be difficult to accept that complete contraction of the lung could follow from such stimuli, it may well be that adhesion section, especially where adhesions are extensive, might provide just such a stimulus.

In five of the cases listed in Table 23 complete atelectasis followed at a short interval from adhesion section, and it is not easy to dissociate the cause and effect in these cases.

Summing up, it may be said, therefore, that in the twelve cases which developed atelectasis followed by empyema the development of both these complications may have been due to

1. the presence of endo-bronchial tuberculosis in major and minor bronchi. Such tuberculous bronchitis is known to be a contra-indication to treatment by pneumothorax.
2. The presence of unhealthy pleura.
3. The effects of adhesion section.

Extent of Adhesions.

The extent of adhesions cauterized was not recorded in the notes , but if it is accepted that the time spent on the operation is directly related to the area cauterized, it is possible to gauge the extent of the adhesions. On the other hand, it is possible that where extensive adhesions existed only the most accessible were divided, and a correspondingly short time would be recorded in the notes.

Tables 25, 26 and 27 show that twenty-seven (60%),of forty-five cases operated upon in which the actual cauterization time is recorded had adhesion sections of more than thirty minutes duration. Five cases (11.1%) had to have two sessions each, of varying duration.

Edwards and Lynn (1939) found that effusion and empyema were more common in cases in which, inter alia, extensive cauterization of adhesions had been performed.

Significance of Adhesions

Positive pressures were used in twenty-four (29.6%) of the eighty-one pneumothoraces to maintain the collapse after adhesion section.

Stobie (1930) suggests that the tearing of an adhesion may result from the use of positive intra pleural pressures during pneumothorax refills, especially when adhesions are disease-bearing areas.

Peters and Wooley (1922) and Fishberg (1932) note that adhesions may prevent small sub-pleural cavities from rupturing into the pleural sac, but it is possible that the use of positive pressures during refills or over-exertion, such as a bout of coughing, may result in the adhesions tearing with the consequent development of effusion and empyema. Goorwitch (1943) considers that empyema follows in cases of unsatisfactory and ineffective collapse, due to mechanical rupture or tearing of adhesions. Weisman (1936) believes that when tubercles are present in the base of the adhesions to the lung, rupture under the action of pneumothorax is the most likely cause of infection of the pleural space. Positive pressures and injudicious refills act only in so far as they rupture a pulmonary lesion bound by

adhesions. Davies (1933), Rosenthal (1936), and Leaver and Hardaway (1937), have expressed similar views.

Morrison (1948) found that of three factors responsible for effusion and empyema in pneumothorax , one was the use of positive pressures during refills.

Adhesion Section -

Adhesion section, per se, appears to have been the chief cause of empyema in seventeen (22.9%) of the seventy-four cases of pneumothorax submitted to operation.

Three of these cases had haemothorax follow adhesion section, while three others suffered traumatic broncho-pleural fistulae.

Six additional cases had broncho-pleural fistulae develop within seven days of adhesion section. If these cases are also to be attributed to operation, it is possible that twenty-three (31.1%) of the seventy four pneumothoraces operated upon had empyema originate from adhesion section.

Goorwitch(1943) considers that many empyemata are due to the severing of adhesions with the accompany-

ing rupture of a pulmonary lesion. Similarly, Gloyne (1926) argues that if an adhesion be severed at a point at which tubercle bacilli can be liberated into the pleural cavity, secondary effusion and empyema are likely to follow.

Regarding haemorrhage following adhesion section, Rafferty (1944) emphasises the danger where there is a large cavity situated close to the pleura suspended by adhesions. Much of the blood supply of the cavity wall may be derived from intercostal arteries through newly formed vessels inside the adhesions.

Korol (1936) draws attention to the possibility of a haemorrhagic effusion as a result of bleeding from the stump of a torn adhesion.

Two cases (2.4%) of the seventy-four cases operated on had adhesion section performed in the presence of acute tuberculous pneumonia. Empyema followed in four and seven days respectively from the date of operation.

Nine cases (12.2%) developed empyema within 7-14 days from adhesion section and were apparently due to operation on inflamed and tuberculous pleurae.

Morrison (1948) found that of thirteen patients in whom the pleura was inflamed at the time of operation, ten developed empyema.

The incidence in this series, of almost 23% of the eighty-one empyemata being due to adhesion section appears high. Morrison (1948), however, had to report the high incidence of 28% of empyemata in thirty-six operations as being due directly to adhesion section,while Andersen (1949), reporting on 54 cases of empyema , found that twelve (22%) resulted from acute reaction following closed pneumolysis and 2.5% followed open pneumolysis. Woodruff(1938) in a series of collected cases found only 5.2% of 154 empyemata which were directly attributable to adhesion section.

Our results compare more favourably with those reported in the literature when considered in comparison with the total number of pneumothoraces reviewed. Only 1.2 % of empyemata are then due to adhesion section which compares favourably with the figures of Chandler (1937) 1.9% , of Anderson and Alexander (1937)3.6%, Brock (1938)1.4% and Wollaston (1940) 2 %.

Adhesion Section during Effusion

Jacobeus (1922) considered that in patients having a serous effusion prior to operation, the outlook was not good because such pleurisies usually become worse after surgical interference. Benjamin (1937) also insists that adhesion section should not be performed during acute pleurisy, but Wollaston (1940) thinks that the stress imposed on a diseased area of lung by the presence of adhesions is so dangerous that the performance of adhesion section, even in the presence of acute effusion, is a justifiable risk.

In this present series of the twenty-seven cases which developed broncho-pleural fistula and had adhesion section, the operation was done in the presence of unhealthy pleurae in twelve (44.4%)

Regarding the cases of empyema which developed within twelve weeks of operation, the pleura was unhealthy in sixteen (66.6%), whereas in those cases in whom empyema did not develop till between twelve and forty weeks of adhesion the number found to have unhealthy pleurae was eight, equivalent to 47%).

It would appear, as would be expected, that where a number of cases are found at thoracoscopy to have unhealthy pleurae, adhesion section will result in a proportionately higher number of empyemata resulting within a few weeks of the operation. Where there has been a progressive effusion, especially if aspiration was necessary before operation, empyema may be expected to follow in about the same time than as where the pleura was unhealthy at operation. On the other hand, the presence of a small puddle of fluid in the costophrenic angle where the pleura is healthy is apparently of no significance.

Development of empyema in these cases and in cases where the pleural space has been dry up to the time of adhesion section depends on other factors.

Cavity Closure after Adhesion Section

Cavity closure was obtained after adhesion section in only fifteen (20.3%) of the seventy-four cases submitted to adhesion section.

Of twenty-six cases classed as satisfactorily collapsed, cavity closure was obtained in eight (30.8%). Of the forty-eight cases classed as either incompletely or ineffectively collapsed after adhesion section, cavity closure was obtained in only seven (14.6%).

In other words, in fifty-nine (79.7%) of the cases submitted to adhesion section, maintenance of pneumothorax after operation failed to control the disease. A proportion of these cases developed broncho-pleural fistulae, as will be described below.

If one adds to the fifty-nine cases in which cavity closure was not obtained after adhesion section the seven cases in whom adhesions were not operable, it can be seen that of the total number of eighty-one pneumothoraces in which empyema developed, disease was not controlled by the collapse in the considerable number of sixty-six, equivalent to 81.5 per cent.

Broncho-Pleural Fistulae

Twenty-eight (34.6%) of the eighty-one empyemata were due to known broncho-pleural fistulae. Nine fistulae occurred within one week of adhesion section; three of these cases were due to trauma at operation, four were due to rupturing of cavities, while two fistulae resulted from rupturing of sub-pleural foci through tuberculous pleurae.

Type of Collapse in cases of Broncho-Pleural Fistula.

Nine cases of fistula occurred in cases satisfactorily collapsed, but in only one of these cases was cavity closure obtained. This patient had a pleura which was found at thoracoscopy to be studded with multiple tubercles. Fistula from rupture of a sub-pleural focus occurred at 16 weeks from operation.

Ten fistulae occurred in cases incompletely collapsed and eight in cases ineffectively collapsed. In none of these cases was cavity closure obtained.

In all nineteen of the total number of twenty-eight, fistulae occurred from rupturing of cavities of the "ballooning" tension type.

Four cases were due to rupture of sub-pleural foci through tuberculous pleurae; three

other cases were traumatic, and one case occurred after four months treatment of effusion and maintenance of collapse by oleothorax.

Broncho-pleural fistula occurred in one patient who was not subjected to adhesion section. He had had a pneumothorax induced while suffering from acute tuberculous pneumonia. Thoracoscopy was performed, but the adhesions were found to be inoperable. Fistula in this case occurred twelve weeks after induction of the pneumothorax.

Five cases which developed broncho-pleural fistula developed complete atelectasis of the lung at varying intervals after adhesion section and prior to cavity rupture taking place.

Causes of Fistula in these twenty-eight cases.

Adhesion section is known definitely to have caused three fistulae, but it is difficult to exonerate the effects of operation in the other six cases which occurred within one week of adhesion section.

Regarding the cases of ruptured cavity, Rafferty (1944) lists inter alia two types of case which are unsuitable for pneumothorax treatment because of the danger of empyema. These are:-

1. Cases of large apical cavity;

2. Cases of endo-bronchial tuberculosis.

In this series, nineteen cases (23.5%) of the total number of empyemata had pneumothorax induced in the presence of a large apical cavity.

Study of the X-rays of these cases would suggest that :

1. Pneumothorax should not have been the treatment of choice, and

2. The pneumothoraces should have been abandoned (a) because the majority were incomplete or ineffective, and (b) because the cavity in each case was of the dangerous ballooning tension type.

Regarding the five cases which developed complete atelectasis after adhesion section. Bronchoscopy was not practised routine in the Sanatorium during the period under review, although no doubt these patients presented physical signs of tuberculous bronchitis. Such endo-bronchial disease may have acted in two ways; on the one hand it may have been the cause of a check-valve mechanism developing, with consequent "ballooning" of tension cavities, and on the other hand may have been the precursor of the complete atelectasis.

Discussing the relationship of broncho-pleural fistula to the occurrence of empyema, Coryllos (1937) is of the opinion that all effusions and empyemata during pneumothorax treatment are due to the developing of large, medium, or punctiform fistulae, while Petroff, Herman & Balitz (1941), in their first series of cases, found broncho-pleural fistula responsible for 75%, and in a second series for 100% of empyemata, 61% of the fistulae having occurred spontaneously, 39% following adhesion section. In my series it is probable that nine cases (32.1%) were due to adhesion section. Simmonds (1941) has suggested that rupture of a cavity is almost the sole cause of effusion and empyema in artificial pneumothorax, while Penington, (1939) in his experiments on rabbits showed that all the cases which developed empyema after pneumothorax showed microscopic evidence of rupture of a sub-pleural intra-pulmonary focus. The majority of such foci which ruptured through the pleura were well localised lesions which proceeded to cavity formation.

Gordon et al (1943) found that tuberculous empyema followed rupture of a caseous nodule which they consider are more common on the front of the lung and the greater movement of the anterior chest

predisposes to their rupture. I have no evidence to confirm this later observation, but their first observation and those of Simmonds (1941) and Penington (1939) have been confirmed in my series of cases.

It would appear that there is evidence for abandoning pneumothorax not only when a large tension cavity develops, and when the collapse is not achieving cavity closure through its being incomplete or inneffective, but also when a tuberculous pleura is found at thoracoscopy.

It has been suggested earlier that cases in which complete atelectasis occurs after adhesion section should also have their pneumothoraces abandoned forthwith.

Summary of Etiology

The principal causes of empyema in this series of cases would appear to have been, in order of importance, -

1. Collapse by pneumothorax of cases unsuitable for such treatment by reason
   - i. Acute activity of the disease;
   - ii. The type of lesion.
2. Maintenance of incomplete and de-selective pneumothoraces, and, most important, those with persistent cavitation.
3. Adhesion section.
4. Broncho-pleural fistula.
5. Maintenance of collapse after development of complete atelectasis and by the use of positive intra-pleural pressures.

Regarding the prevention of empyema in comparable cases. It would appear that the choice of case for pneumothorax treatment should rigidly exclude those types listed in Table 18.

With the recognition of the fact that almost all cases of parenchymal tuberculosis have associated endo-bronchial disease of greater or less degree of

severity, there would seem to be a place for routine bronchocoscopy before and after induction of pneumothorax, especially now, when this type of disease is known to respond well to streptomycin treatment.

Alternative treatment for patients with disease unsuitable for pneumothorax treatment has been made available to a greater extent now, with the discovery of streptomycin and para-amino salicylic acid, and the advances in thoracic surgery.

So far as activity of disease is concerned at the time of induction of pneumothorax, the shortage of beds at the present time has not made easier the opportunity of allowing a patient prolonged bed rest prior to induction of pneumothorax. To compensate for this deficiency, and in order to reduce activity of disease, there seems a place for pneumo-peritoneum with or without phrenic crush for a preliminary period to allow the disease to "cool off".

Pneumothoraces which cannot be rendered satisfactory by adhesion section should be abandoned at the time of operation.

Satisfactory anatomical collapses, where they are not achieving cavity closure, might reasonably

be abandoned and alternative treatment considered.

Adhesion section will inevitably carry a risk of post-operative complications. The operability or otherwise of adhesions and the extent of area to be cauterized must be left to the judgment of the operator.

Broncho-pleural fistula should be avoidable by observing the principles mentioned already, regarding choice of case for pneumothorax and maintenance of collapse. Collapse should not be induced unless adhesion section facilities are available, and the operation can be performed in a reasonably short time after induction. Positive pressures should not be used to maintain collapse.

Regarding the development of complete atelectasis it has already been suggested that cases in which this occurs should have their pneumothorax abandoned despite complete re-aeration in a short time.

DISCUSSION

Treatment and Results

Generally, treatment of both pure and mixed types of tuberculous empyema can be divided into two broad classes -

1. Conservative;
2. Radical or surgical.

Conservative treatment may range from "watchful neglect" through the different stages of aspiration, to pleural lavage with antiseptics and instillation of drugs into the empyema space.

Radical treatment covers all the major surgical procedures, such as thoracoplasty, with or without decortication of the lung, extrapleural plombage with plastic polythene pack and more recently pleuropneumonectomy.

Hitherto, the presence of secondary pyogenic infection vastly altered the fundamental approach to treatment, but the availability of penicillin and other antibiotics has allowed the treatment of both pure and mixed empyemata, at least in the early stages, to proceed on more or less identical lines.

Pure Tuberculous Empyema.

"Watchful neglect" or adoption of the attitude that most cases of tuberculous empyema are best treated by no treatment has been advocated in the past by the Committee of the American Sanatorium Association (1931), by Chandler (1942), Ornstein & Ulmar (1939), Duboff (1919) and Coryllos (1937). Fishberg (1932) contends that this type of "treatment" may be used occasionally, but Woodruff (1938), in an account of 154 cases of tuberculous empyema, observed over a period varying from three to eight years, found only six cases in which no active treatment was given. Of these six cases, two were dead, two were alive, but were invalids, and two were well and working. Rickey (1943) states that in his experience, cases successfully "treated" by doing nothing are very few and that sooner or later the vast majority develop broncho-pleural fistulae or pleuro-cutaneous sinuses. Skavlem et al (1940), in a report on treatment of tuberculous empyema, found that with what they termed "indifferent" treatment consisting of bed rest, opiates and occasional aspiration, forty out of a total of forty-one patients subjected to this regime died in hospital.

In my series of seventy-eight patients, none were treated by "watchful neglect". Conservative treatment was used in sixty-nine patients (88.5%). As has been pointed out in Section I, Table 16, only two (2.5%) of the seventy-eight patients had a contralateral lung clear of disease although twenty (26.3%) of the remaining seventy-six patients had a minimal degree of contralateral disease. It is not surprising, therefore, to find that only nine patients (11.5%) of the total of seventy-eight were treated by thoracoplasty; indeed, this is a fairly high proportion for it means that a number of patients with contralateral disease were, in fact, treated surgically and the results, as shown in Table 48, seem to have justified the risk.

It would appear, therefore, that in this series, conservative treatment (as the final form of treatment) was adopted because there was no alternative. In these patients, therefore, no real permanent control of the underlying lung disease was attempted, although in 25 patients the pneumothorax was maintained, as shown in Table 78.

It is surprising, therefore, to find that in Group A (pure tuberculous empyema) of thirty-nine

patients treated conservatively, seventeen (43.6%) are alive. Survival in some of these cases has been ten years and eight years down to 3½ to 4 years, which was the maximum possible since onset of the empyema.

In Group B (the pyogenically infected group of empyemata), thirty patients, involving thirty-two empyemata, were treated by conservative methods and only seven (23.3%) are alive.

Individual Methods of Treatment.

1. Aspiration and Air replacement -

This was the simplest treatment adopted, where attempt was being made (not necessarily wisely) to maintain the pneumothorax.

In Group A, seventeen cases were treated by this method. Of these, seven (41.2%) are alive, nine (52.9%) are dead, and one case (5.9%) was lost sight of.

In Group B there were only six cases which included seven empyemata, in that one patient had bilateral empyema. Of these six patients four (66.6%) are dead, and two (33.3%) were lost sight of.

Of the total number of twenty-three cases, in both groups treated by this method, seven (30.4%) are alive, thirteen (56.5%) are dead, and three (5.1%) are lost sight of.

Of the seven patients in Group A who are alive and were treated by this method, four had unilateral pneumothoraces and three bilateral pneumothoraces. Six patients are well and working (two with re-expanded contralateral pneumothoraces), while one is not well nor working. Survival from onset of empyema in these seven patients varies from $8\frac{1}{2}$ years to the maximum possible of 4 years.

These results compare not unfavourably with those of Woodruff (1938), who found that of thirty-eight patients in Group A treated by simple aspiration and air replacement and studied over a period of from three to eight years, twenty-three (60.5%) have survived and fifteen (39.5%) are dead.

Of the twenty-three survivals, fifteen (65.2%) are well and working and eight (34.8%) are not well nor working.

Of six patients in Woodruff 's Group B (secondarily infected cases) five (83.3%) are dead. One patient is alive, but is not able to work.

2. Aspiration and Pleural Lavage with Antiseptics and Dyes.

The Committee of the American Sanatorium Association (1931) reported that most sanatorium physicians were of the opinion that intrapleural injection of chemical solutions seemed to be of more use than air replacement alone, but was of little value in the successful treatment of empyema. In the pyogenically infected cases it was thought that chemical solutions might be used in attempts to sterilize the pleural cavity, but no particular chemical could be recommended. This latter contention is supported by reports in the literature of experiments with all manner of solutions such as gentian violet, acriflavine, mercurochrome, methylene blue, brilliant green, and many others. Their very number and variety were proof of their inefficacy.

Following reports on Azo-chloramid and sodium tetra-decyl sulphate (Azo T.) by Petroff, Herman and Palitz (1941) and Munro-Ashman & Tate (1943) this solution was adopted by the Cheshire Joint Sanatorium for routine use in tuberculous empyema.

Azo T. solution alone, or in combination with one or other solution such as ensol, normal saline, methylene blue, acriflavine and Carrel-Dakin

solution was used in twenty-three (29.5%) of the seventy-eight patients.

Seventeen (73.9%) of these twenty-three cases were in Group A and six (26.1%) were in Group B.

Of the seventeen Group A cases, seven (41.2%) are alive, nine (52.9%) are dead, and one case (5.9%) was lost sight of. These results are similar to those obtained in cases treated by simple aspiration and air replacement only, with equal numbers of patients. All seven survivors in Group A are well and working, two having survived ten years from onset of empyema and the others varying periods uo to the maximum possible of four years. One patient who had a contralateral pneumothorax has survived six years.

In Group B, of a total number of six cases treated by these methods, four (66.6%) are dead, one case is alive and one was lost sight of.

Woodruff (1938) reported on seventy-six cases treated by the above methods. Forty-three (56.6%) were in Group A, and thirty-three (43.4%) were in Group B. His results were:-

Group A Cases - total number forty-three.

Alive - twenty-eight (65%), of whom fourteen (50%) were well and working.

Dead - fifteen (35.1%)

Group B - total number thirty-three.

Alive - fourteen (42.4%) of whom five are well and working.

Dead - nineteen (57.6%).

My results compare with these as follows:-

Group A - Total number seventeen.

Alive - seven (41.2%)

Dead - nine (52.9%)

Lost sight of - one (5.9%)

Group B - Total number six.

Alive - one (16.7%).

Dead - four (66.6%)

Lost sight of - one (16.7%)

It would appear, as would be expected, that survival depends in the first place, in maintaining freedom from secondary infection in the pleural space.

My own results and those of Woodruff already quoted, suggest that in Group A cases aspiration

followed by lavage has little if any advantage to offer compared with treatment by simple aspiration and lavage with Azo T alone or in combination with other solutions.

Reports of treatment by aspiration and lavage found in the literature show conflicting views and varying results.

Jones and Alexander (1934) state that "reliance upon nothing but prolonged aspirations with or without antiseptic irrigations or instillations.... inevitably result in a shockingly high mortality." These workers report of five cases they treated by these methods and all died.

Gordon, Charr & Savacod (1943), on the other hand, speak well of repeated aspiration and irrigation with normal saline in pure tuberculous empyema. They qualify their remarks, however, by suggesting that success can only be expected if the lesion in the lung is well controlled. It would appear that one should reasonably not expect empyema to develop in cases of pneumothorax where the pulmonary lesion is controlled.

Cutler (1941) reported good results also with aspiration and irrigation with normal saline. Coello (1947) considers it is justifiable to start treatment

by aspiration alone or aspiration and lavages, but this treatment should not be persisted in too long for the gradual thickening of the pleura may render the final thoracoplasty too extensive or too traumatic. This would suggest that the writer envisages thoracoplasty as inevitable in the final event.

Heaf & Rusby (1948) state that pleural aspiration and lavage will clearly give the best results in those patients in whom empyema occurs late in the course of pneumothorax treatment, for by this time the pulmonary lesion will probably have healed.

Hoyle (1943) takes the opposite view and doubts whether lavage does anything more than clean the pleural space. He contends that there is nothing in the pharmacology of the many antiseptics used for lavage to suggest that any of them can control the tuberculous proeess, and even if they could, it is difficult to see how such an action could be brought to bear on the depths of the pleura where it is most wanted, merely by surface lavage. But aspiration with or without lavage, nevertheless, is an effective measure for the control of toxaemia and

for assisting re-expansion of the lung. Only indirectly in this way does it affect the ultimate outcome for this depends on other things.

3. Aspiration Lavage and Injection of Sulphonamide Powder or Penicillin in Saline Intrapleurally.

Six cases, all in Group B, were treated by lavage with Azo T solution, normal saline supplemented by injections of sulphonamide powder in saline, or penicillin intrapleurally.

Five of these six cases are dead and only one is alive. This patient has survived 3½ years from the onset of empyema, but is not well nor working.

Of the five who died, one survived 4 years and another two years and nine months. The remainder died within a matter of months from the onset of empyema. There is no doubt the addition of secondary infection carries a very high mortality.

Three cases which received penicillin cleared their infection; none of those which received sulphonamide powder cleared their secondary infection.

4. Aspiration Lavage and Final Closed Drainage.

Eight patients were treated by these methods as the final form of treatment. Seven (87.5%) are dead. The patient who has survived has lived seven and a half years from onset of his empyema and is now well and working. A surprising feature of this man's case is that tube drainage was continued for as long as thirteen months, while at the same time he had a contra-lateral pneumothorax.

Various solutions, such as Azo T, 1/2000 flavine, normal saline, and sulphonamide powder in cod liver oil were used for intrapleural lavage and injection in these cases. Four of these eight patients had broncho-pleural fistulae. Of the seven cases which are dead six died within six to eighteen months of the institution of tube drainage. The other case had his tube inserted as an out-patient and no record is available of when this was done. He survived in all 5½ years from onset of empyema.

The high mortality rate in my series of patients treated by these methods compares unfavourably with the results reported by Woodruff (1938). His series included thirty-three patients treated by tube drainage, of whom twenty-one (63.6%) were reported

as dead. Of the remaining twelve patients, only three were well and they had had thoracoplasty as their final treatment.

All Woodruff 's cases were followed up for periods of from three to eight years.

Davidson (1941) instituted tube drainage as a first step in treatment in 125 cases. Thirty-eight cases who had this as their only form of treatment were all reported to be dead in a relatively short time.

Leaver and Hardaway (1937) had a mortality rate of 71% where tube drainage was the sole treatment, while Brock (1943) had a mortality rate of 91%.

The Committee of the American Sanatorium Association (1931), in their investigation into the methods and results of different sanatoria in treating empyema reported a mortality rate of 50% for closed drainage and 56% for cases treated by open drainage.

There is no doubt about the very high mortality rate in cases of empyema treated by open or closed drainage.

In my series, three pure tuberculous empyemata were drained, but five other cases had already their secondary infection at the time drainage was started.

Of tube drainage of pure tuberculous empyema Alexander (1937) says "Under no condition that I know should a pure tuberculous empyema be drained with a tube." No one would disagree with this. As far as the drainage of secondarily infected cases is concerned Brock (1943) considers it may do some good provided thoracoplasty can be done in as short a time as possible after drainage is started.

In this series only two cases were suitable for thoracoplasty after tube drainage; these will be considered under the heading Thoracoplasty, and are not included in the eight patients mentioned above.

Oleothorax.

Twelve patients in this series had oleothorax. Three came to thoracoplasty. In the nine patients in which oleothorax was the final line of treatment, are included ten empyemata, in that one patient had bilateral oleothorax and empyema. Of these nine patients five are alive (including the patient with bilateral empyema) and four are dead.

Five patients were in Group A and three of these are alive, while two are dead. Four patients were in Group B. Two of these cases are alive and two are dead. Details of the duration and type of oleothorax used in the nine cases so treated are

given in Tables 64 and 65.

Survival from onset of empyema in the three Group A patients still alive is, so far, 7 years, 8 years and 8 years. Of the two Group A patients now dead, survival from onset of empyema was 8 years and 2 months and 4 years respectively.

In the Group B cases the two patients who are alive have survived $6\frac{1}{2}$ and 6 years respectively. This latter patient had bilateral empyema and is still having occasional aspirations of the right empyema.

The two cases in Group B who are dead survived 4 years and 1 year and 2 months respectively.

Two patients who were treated by oleothorax had broncho-pleural fistulae, one before oleothorax was instituted and the other four months after oleothorax was started.

Of the nine cases in this series treated by oleothorax, six got pleuro-cutaneous fistulae. Nevertheless, five (55.5%) of the total of nine patients in whom oleothorax was the final form of treatment have survived fairly long periods (from 8 years to 6 years) since the onset of empyema.

Woodruff (1938) found oleothorax second to thoracoplasty in the successful treatment of tuberculous

empyema. Alexander (1937) quotes results of different workers showing that of 127 cases treated by oleothorax, eighty (63%) were satisfactory and forty-seven (37%) unsatisfactory after an observation period of six years.

Leaver and Hardaway (1937) made oleothorax their first choice in treatment. In thirty-five cases they reported eighteen (51.4%) cures. Matson (1932) in an exhaustive paper on oleothorax found that of fifty cases treated by this method, satisfactory results were obtained in thirty (60%), while twenty (40%) were unsatisfactory. Skavlem et al (1940), on the other hand, reviewing forty cases reported that only thirteen (32.5%) could be classed as "recovered" and fourteen (35%) had died.

Browning, Dundon and Ray (1941) in a report on forty-eight cases of empyema, concluded that cases in whom a good permanent collapse is desired and who are good surgical risks, should have thoracoplasty. All others should have oleothorax. These conclusions were based on a "cure" rate of nearly 70% and a mortality of only 10.4% using oleothorax as the final form of treatment.

Hoffman and Kettler (1943) state that in their opinion oleothorax will postpone or entirely avoid subsequent thoracoplasty.

Howlett quoted by Alexander (1937) has pointed out that results with oleothorax tend to correspond with the general course of the tuberculous disease. With uncontrolled parenchymatous disease oleothorax is, therefore, of little value.

Hayes (1941) has advocated the use of oleothorax in cases of tuberculous empyema complicated by unexpandable lung, while Alexander (1937) considers oleothorax is indicated only when continuation of pulmonary collapse is desired in cases in which the empyema has produced an obliterating pleuritis.

Thoracoplasty.

Thoracoplasty was performed in nine cases. Five were in Group A and four in Group B. Seven patients had thoracoplasty done in the presence of minimal, and two in the presence of moderate contralateral disease.

All five Group A patients are alive and two of the four Group B cases are alive. One of the Group B cases is dead and the other was lost sight of.

Thus seven out of nine cases treated by thoracoplasty are alive - a survival rate of 77.7% - and all are well and working.

Details of the preliminary treatment and its duration before thoracoplasty are given in Table 66. Only three cases had thoracoplasty done within six weeks from the start of other treatment, while one case had had twenty months of previous treatment which included closed drainage.

Survival of the thoracoplasty cases ranges from eight years to three years and nine months from the onset of empyema and from seven and a half to almost three years since the last stage of thoracoplasty.

These figures show that of the various treatments used, thoracoplasty has given the best results with nearly 78% of cases recovered and able to work.

Figures reported by other investigators confirm these findings. Jones and Alexander (1934) reported 74% of cures by thoracoplasty; Woodruff (1938) 79%, Skavlem et al (1940) 62.5%, Brock (1943) 95%, Rose (1948) 73%.

Andersen (1949) reporting on fifty-five cases treated by thoracoplasty found that forty-one (74.5%) were satisfactory, two (3.5%) were unimproved, and twelve (22%) dead.

Of nineteen cases treated by non-surgical methods, only one was cured, one was improved, and fourteen (73.7%) were dead.

The reason for the success of thoracoplasty is undoubtedly that besides closing the empyema space, control of the underlying lung disease is achieved simultaneously, and apparently more efficiently than with other forms of treatment.

Unfortunately, however, since tuberculous empyema occurs classically in the patient with bilateral fibro exudative disease, few patients are suitable for thoracoplasty.

Oleothorax and Thoracoplasty.

In comparing the results of treatment of tuberculous empyema by oleothorax and by thoracoplasty, the survival of 55.6% of the cases treated by oleothorax, compared to 77.8% for thoracoplasty, is not unsatisfactory. One of the oleothorax cases had bilateral empyema, with secondary infection on the right side.

In this series, two patients who had oleothorax were put to the surgeon for consideration for thoracoplasty but were turned down; the other seven cases treated by oleothorax were not even considered for

thoracoplasty. In other words, oleothorax can be used in cases which might be considered at the start will never be suitable for thoracoplasty. Moreover, the better results for treatment by thoracoplasty are weighted by the fact that these cases have had, from the start, lesions that were amenable to successful thoracoplasty treatment. On the other hand, selection of cases for thoracoplasty must be far more exclusive than for oleothorax.

Against olebthorax as a method of treatment is that even successful cases carry a risk of certain late complications not experienced by these treated by thoracoplasty such as broncho-pleural fistula, pleuro cutaneous sinuses and recurrence of empyema.

One case in my series got a broncho-pleural fistula and six of the total of nine cases got chest wall sinuses. Skavlem et al (1940) considered that their method of not completely filling the pleural space with oil avoided these complications, but this has not been confirmed by others.

Oleothorax has long been abandoned in the Cheshire Joint Sanatorium. In suitable cases, thoracoplasty or pleuro-pneumonechomy is now the treatment of choice.

Results of Various Types of Treatment

Tables 48 and 69 would suggest that the two important factors for successful final treatment of tuberculous empyema are -

1. The avoidance of secondary infection ;
2. The conversion of sputum.

Secondary Infection of Empyema

Nearly sixty-eight per cent of the thirty-four secondarily infected cases are dead, compared with a little over forty-five per cent of the non-infected Group A cases.

Secondary infection arose from broncho-pleural fistula in eighteen (51.4%) of the thirty-five empyemata in Group B , while fifteen (42.9%) were infected during treatment such as aspiration.

It is permissible to suggest that almost half the Group B cases could have been spared the consequences of a mixed infection by obliteration of the pleural space at an earlier stage. In other words, the sooner the secondarily infected case can be got ready for thoracoplasty, the better, if the condition of the contra-lateral lung justifies the risk. The

pleural space will be obliterated, the homolateral pulmonary disease will be brought under control with proportionate reduction in the period during which he is exposed to contralateral spread and the consequences of chronic pyogenic infection.

Regarding other forms of treatment of the secondarily infected case. Penicillin and the newer antibiotics may achieve much in the way of eliminating or reducing secondary infection after it has occurred, but there is always present the risk of persistent non-sensitive strains of organism remaining or developing.

Aspiration either alone or combined with lavage or tube drainage are of very little value. Table 48 shows that of twenty-six patients treated by such methods, only three (11.5%) are alive, and they are not well. Two of the four patients treated by oleothorax are alive, but they are not well and one case is still having aspirations 6 years after onset of empyema.

Conversion of Sputum

Table 69 shows that fifty-six patients were discharged from hospital.

Of the total of seventeen discharged with a positive sputum, thirteen (76.5%) are dead, and only four (23.5%) are alive.

On the other hand, of thirty-nine patients discharged with either no sputum or a negative sputum, twenty-five (64.1%) are alive and fourteen (35.9%) are dead.

It has been our experience in the Cheshire Joint Sanatorium that patients discharged with a positive sputum and a rising blood sedimentation rate have the poorest prognosis, and it was hoped to attempt to correlate length of survival according to sputum and sedimentation rate at discharge. Table 71 shows a trend in the direction that in patients with a positive sputum at discharge, length of survival is related to the rapidity or otherwise of the sedimentation rate at discharge, but Tables 72 and 73 do not show that trend and seem to bear out that either no sputum or a negative sputum is more important than a rapid sedimentation rate at discharge.

Treatment of Group A Cases

In treatment of Group A cases, thoracoplasty is the most successful treatment, with oleothorax apparently the second best. As few cases are suitable

for thoracoplasty and oleothorax carries the risk of late complications. one is left with only aspiration (plus lavage) as the available treatment.

It seems from Table 48 that one can hope for about 50% success with these methods of treatment, but before such treatment is embarked upon it must be decided whether the collapsed lung will be worth re-expanding later. Table 78 would suggest that the risk may be worth while. On the other hand, one is taking the additional risk of the dangers of treating prolonged empyema, and even the re-expanded lungs, in the presence of much disease, are frequently physiologically poor lungs. Table 78 shows that of fifty-three cases in whom the collapse was abandoned, thirty-two (60.4%) are dead, and only seventeen (32%) are alive, against 44% dead and 48% alive in cases in which the collapse was maintained. It would appear, therefore, that each case would have to be judged on its merits as to whether collapse should be maintained or abandoned forthwith on the occurrence of empyema.

It is unfortunate that the type of case in which empyema is most likely to occur and in the event is most common, should for the same reasons be the case in which any form of surgery is most hazardous.

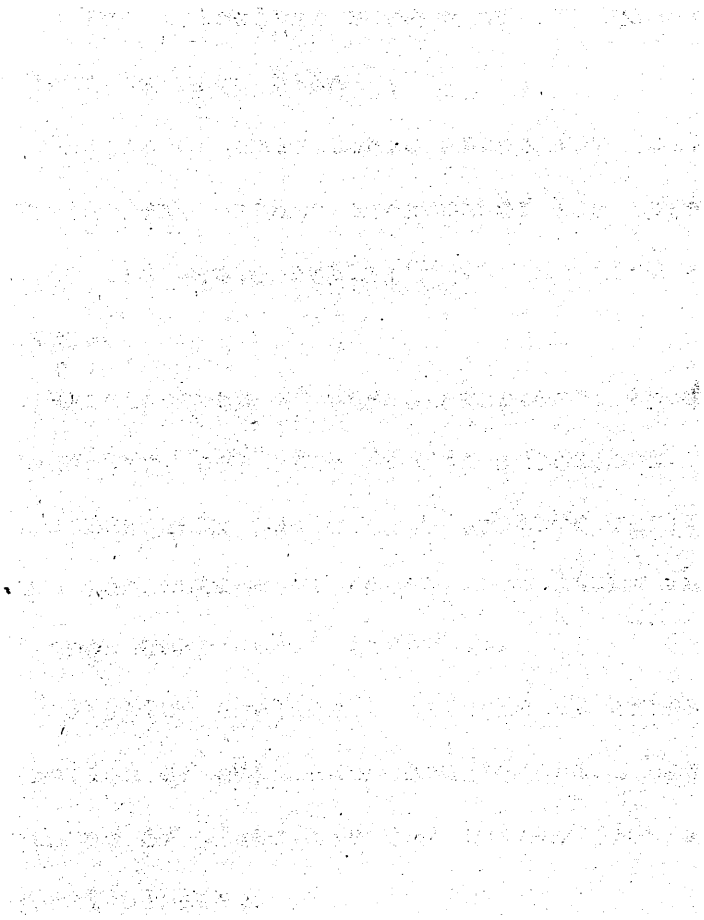
Modified surgery (if it can be so called) such as decortication of the lung and attempt to close the empyema space by extra-periosteal polythene pack has been attempted in our Sanatorium, but has not met with success.

Thoracoplasty, and lately pleuro-pneumonectomy where the lung is very poor physiologically, are the only forms of surgical treatment now used. Both involve drastic surgery, but offer the chief hope of successful treatment of tuberculous empyema. The need, therefore, is to direct treatment to raising the proportion of patients in whom surgery would become a practical possibility.

Streptomycin, combined with Para-amino salicylic acid with or without phrenic crush, and pneumo-peritoneum as a preliminary treatment, might by controlling contralateral disease increase the number of patients ultimately suitable for thoracoplasty. Pleuro-pneumonectomy is possible only in those patients in whom the contralateral lung is shown by tomography to be completely clear of disease.

Finally, it has to be admitted that there will occur cases of tuberculous empyema during artificial pneumothorax treatment, for which little can be done

other than by so-called conservative methods, and that at least half these cases are destined for an early death.



SUMMARY AND CONCLUSIONS

The incidence of tuberculous empyema in artificial pneumothorax is reviwed.

The etiology of eighty-one cases of pure and pyogenically infected empyema in seventy-eight patients is reviewed and discussed.

The principal causes of empyema in this series seem to have been-

1. Choice of unsuitable cases for collapse by pneumothorax, either because of the type of disease or its acute activity at the time of induction of collapse.
2. Maintenance of unsatisfactory, ineffective or de-selective collapse due to adhesions.
3. Consequent failure to achieve cavity closure in a high percentage of cases, resulting in development of broncho-pleural fistulae.
4. Adhesion section , especially extensive cauterization of adhesions and adhesion section in the presence of pleuritis and active pleural or sub-pleural disease.
5. Maintenance of collapse after complete atelectasis had occurred.

A review of treatment and survival of patients following varying forms of treatment is presented.

The avoidance, or successful elimination of secondary pyogenic infection is the first essential in treatment.

Surgical treatment in suitable cases is the treatment of choice. In cases unsuitable for surgical treatment there is some evidence to suggest that maintenance of pneumothorax is worth attempting in cases classed as satisfactorily collapsed at onset of empyema, provided sputum conversion has been obtained.

The results of treatment would also appear to show that in pure tuberculous empyema, aspiration and lavage with antiseptics and dyes etc. offers no advantage over aspiration and air replacement alone.

Oleothorax is prone to complications, especially the formation of chest wall sinuses. This may prevent thoracoplasty being done in a case otherwise suitable for operation.

Prevention of Empyema.

The best treatment for empyema is to prevent it. This involves

1. The choice of more suitable cases for treatment by pneumothorax.

Pneumothorax should not be induced in:

1. Cases of acute tuberculous caseous disease. Such cases might be treated by pneumothorax after a course of streptomycin and para-amino salicylic acid with or without accompanying phrenic crush and pneumo-peritoneum and preferably after the sedimentation rate has fallen below 40 m.m. in 2 hours (Westegren).

2. Cases with extensive destruction of tissue.

3. Cases of large apical cavity.

4. Cases of multiple cavitation.

5. Cases of endo-bronchial tuberculosis.

These might have preliminary treatment with streptomycin and para-amino salicylic acid and if bronchoscopy should show clearing and healing of the lesions and no severe degree of broncho-stenosis pneumothorax might be attempted.

While an adequate period of bed rest is perhaps desirable before induction of pneumothorax, the need for rapid bed turn over at the present time precludes this course. Phrenic crush and pneumo-peritoneum will achieve the same end in a shorter time.

Pneumothorax should be abandoned in :-

1. Cases of de-selective, incomplete and in-effective collapse, including those requiring positive

intra-pleural pressures to maintain the collapse.

2. Cases with multiple adhesions which would involve extensive cauterization.

3. Cases in which pleuritis and tuberculous pleurae are found at thoracoscopy.

4. Cases which develop sufficient fluid before adhesion section as to require aspiration.

5. Cases in which the collapse is not succeeding in closing a cavity or cavities even although the collapse is anatomically and radiologically satisfactory.

6. Cases in which complete atelectasis occurs even if complete aeration follows bronchoscopy in a short time and even although the collapse appears to be satisfactory.

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